

GLOBAL WARMING: WHAT WE CAN DO NOW

OCTOBER 1989

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1990
AMERICAN
CARS—GOOD AS
THE IMPORTS?

Popular science

B-2

WHAT STEALTH'S FIRST FLIGHT REVEALS



T IS US.

comes standard on all Ranger and Bronco II 4x4s, and is available as an option on all Broncos.

This year, Ford is introducing a more powerful V-6 engine that will be available on Ranger.††

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And why the toughest competition we have is ourselves.

*Based on latest available 1989 model year manufacturers' reported retail deliveries by division. **Based on calendar year manufacturers' reported retail deliveries through 1988. †Based on 1988 New Car and Truck Buyer Study. ††See your dealer for availability.



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AND IT

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WE HAVE MET
THE
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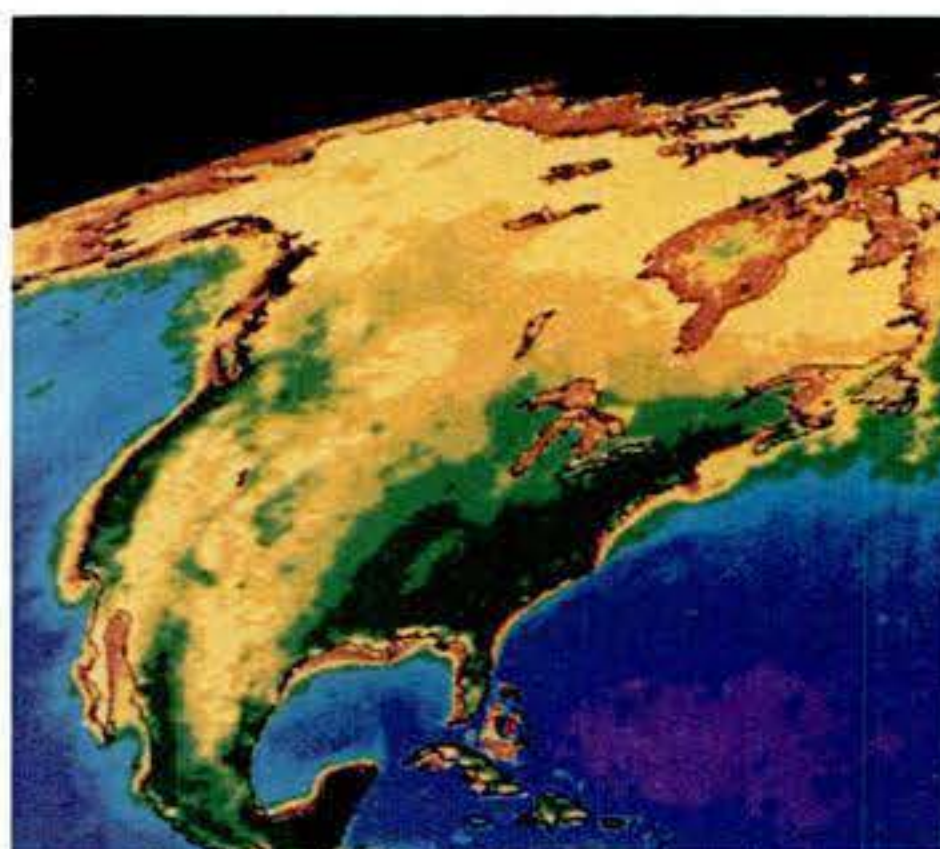
COVER STORY

B-2

After a decade of development, the B-2 has finally flown, revealing a clearer picture of its design and technology. But now criticism is shifting to other areas of the B-2 program: Does the United States need another strategic bomber, and is the B-2 worth its half-billion-dollar price tag? **Page 45**

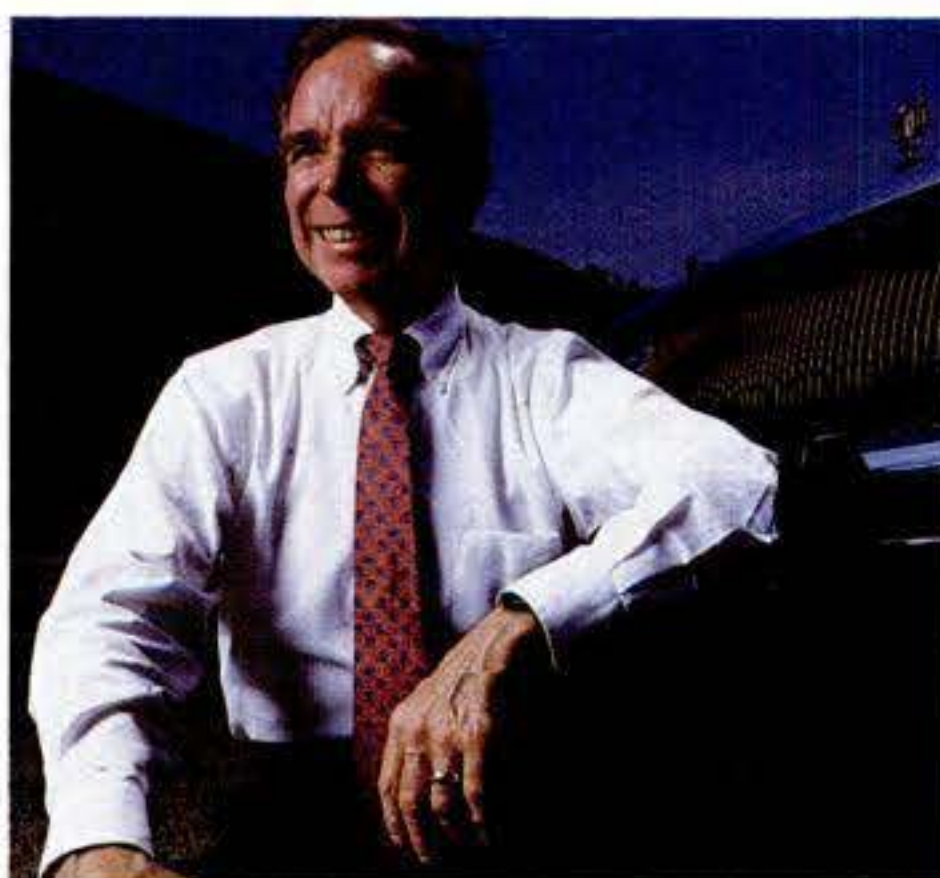
Saving the planet

The experts agree: Global warming may be the most pressing international issue of the century. The final part of this three-part series examines the proposals to counter the pace of this potential catastrophe. **Page 51**



Good as the imports?

Are American car makers finally achieving world class status? POPULAR SCIENCE interviews industry leaders and observers to find out whether Detroit's fortunes are on the rise or if major hurdles still lie ahead. **Page 57**



Home heating

A humidifier that atomizes water; a remote-controlled fireplace door. These and other products could help warm up your home. **Page 71**



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What's News

Uncovering the B-2 bomber

POPULAR SCIENCE has published three cover stories on the stealth bomber [Feb. '83, Sept. '86, July '88]. The cover illustrations were artist renderings based on information uncovered by our editors and writers despite a curtain of Air Force secrecy. Although we have photos of an actual B-2 in flight, along with eyewitness observations of the giant craft, many of its engineering details are still top secret. However, POPULAR SCIENCE editors have used the photos and expert analysts to uncover new insights into the engineering, design, and capabilities of the giant flying wing. What emerges in C. P. Gilmore's report, starting on page 45, is an aircraft that is arguably the most amazing ever built.

Global warming

This issue includes the third and concluding article in our series on global warming, written by Science and Technology Editor Arthur Fisher. We're especially proud of the series because we believe it is the first comprehensive overview of this worldwide threat in a major magazine.

The first, "Playing Dice with Earth's Climate" [Aug.], explored the background of the threat: how the activities of a burgeoning and increasingly industrialized world have enhanced the greenhouse effect by increasing the amount and number of greenhouse gases in the atmosphere. It also detailed the climate modelers' best estimates of the socially disruptive and potentially catastrophic consequences of even a modest rise in global average temperature: widespread flooding due to rising sea levels; drastic changes in vegetation, including food crops; and an increase in weather extremes.

Part two of the series, "Inside the Greenhouse" [Sept.], examined the sources and roles of the greenhouse gases—carbon dioxide, methane, nitrous oxide, ozone, and the CFCs—in the workings of the greenhouse effect. That is the process by which the atmosphere traps just the right fraction of the sun's energy and maintains the delicate balance that keeps Earth's temperature neither too hot nor too cold for life to exist.

This issue's installment, "Saving the

Planet," examines the real prospects for slowing the inevitable changes in our environment. Can energy options such as solar, wind, hydro, and others make a dent in reducing carbon dioxide emissions? Should nuclear energy play a larger role? Or is relying on conservation the most promising route to salvation?

Science-writing honor

The author of the "Global Warming" series, Arthur Fisher, has added to his impressive list of honors for science writing. He was recently elected as a director of perhaps the most prestigious organization for science writers: The Council for the Advancement of Science Writing. A small handful of the country's most respected science writers and scientists make up the board of directors of this organization.

Car quality

Our premier car tester, Don Sherman, tackles an intriguing question this month: Is domestic car quality catching up to the imports? Don discusses how one U.S.-built car, the Buick Le Sabre, has vaulted into the top 10 in the highly respected J. D. Power and Associates Initial Quality Survey—landing in second position, the highest rating of any American car. The survey results, released in June, seem to have had immediate results for Buick, which sold 9,697 Le Sabres in the first 20 days of July, compared with 4,541 in the equivalent period last year.

Tilt-rotor planes

Will you be flying in one of these aircraft soon? The possibility seems a little closer to reality. The Federal Aviation Administration recently gave the California Department of Transportation \$200,000 to study using the Bell/Boeing V-22 Osprey [July '87] for passenger service in that state. The study will take 12 to 18 months. The FAA has also funded similar studies in eight other states.

U.S. plant for two-stroke

The clever two-stroke engine designed by Ralph Sarich [Feb. '87] appears to be close to production for marine use.

Continued

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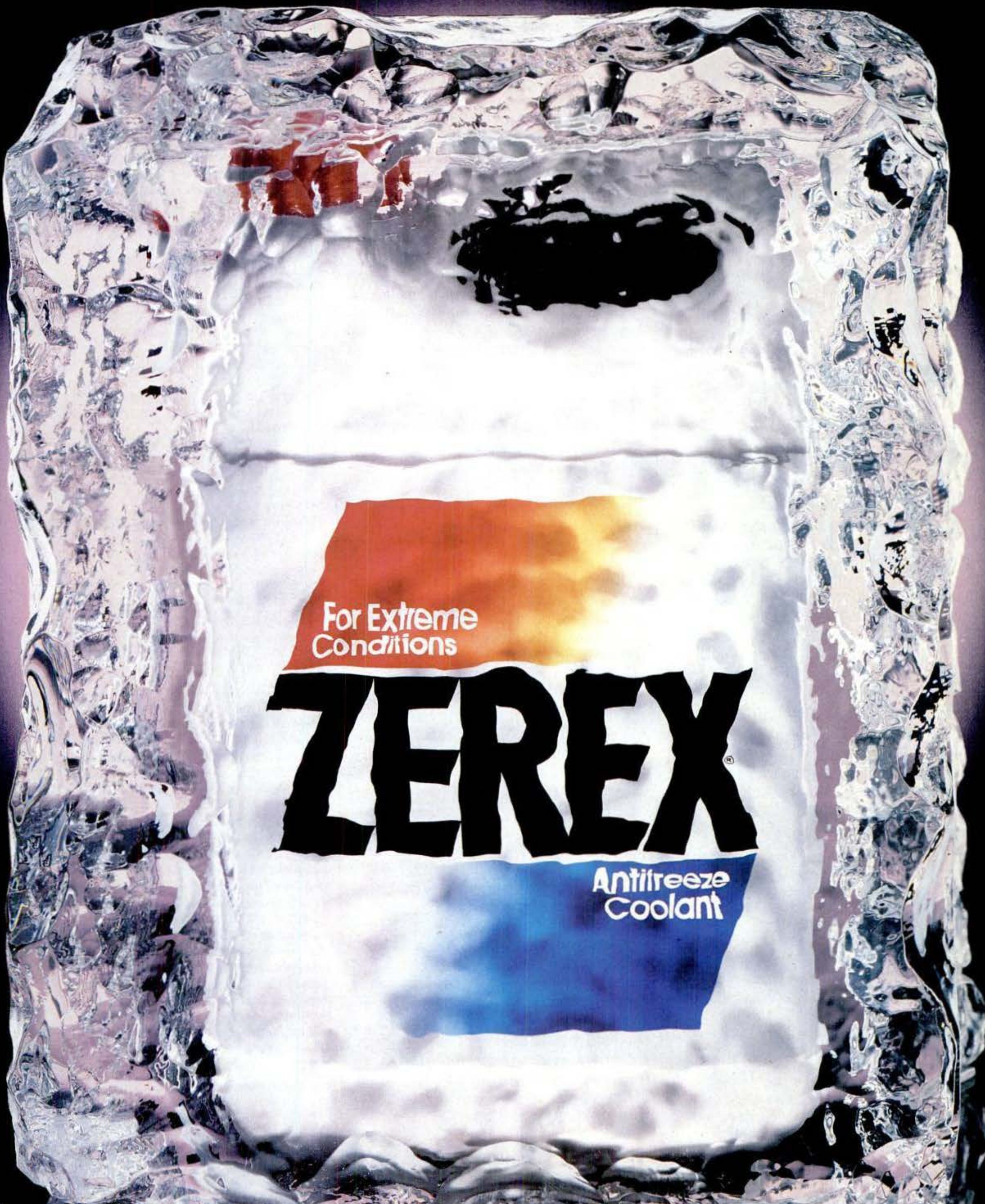
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For Extreme
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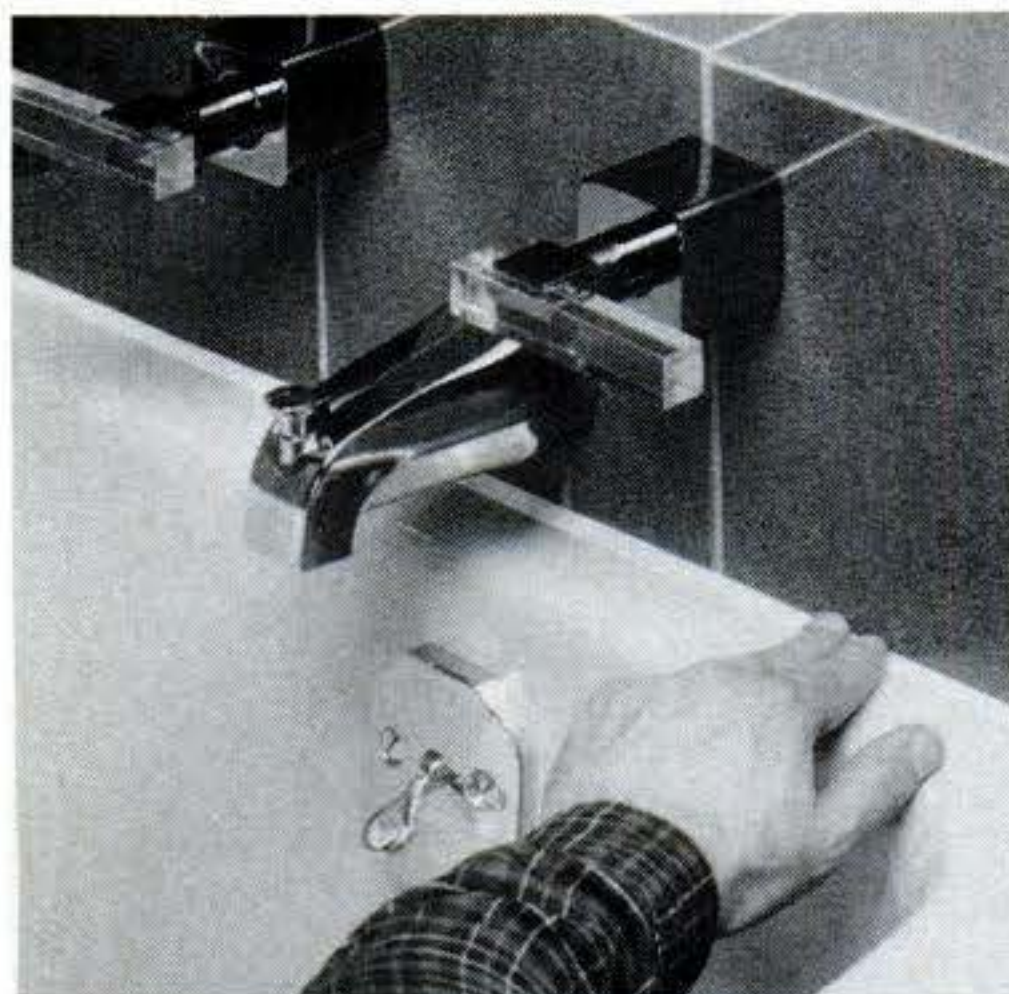
ZEREX

Antifreeze
Coolant

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Simple Solutions to Five Common Caulking Problems



If you're among the millions of American homeowners faced with a caulking problem this year—and dreading such annoyances as a clogged gun, or caulk that pours out too quickly (or too slowly)—relax! 3M offers simple solutions to take the mess and stress out of five common caulking tasks. It's just a matter of pressing your problem into place.

PROBLEM #1: TUBS AND SINKS

To repair ugly gaps and cracks around bathtubs, sinks and shower stalls and prevent costly moisture damage, use Press-In-Place® Tub & Sink Caulk. Just dig out the old compound, scrub the joint with detergent, rinse, wipe with alcohol and let dry. Then, unroll the pre-formed bead of caulk right over the crack, press it in place with your finger tip and trim to fit with ordinary scissors.

PROBLEM #2: DOORS AND WINDOWS

Eliminate energy-leaking cracks and gaps with Press-In-Place® Door & Window Caulk. The caulk withstands a wide range of temperatures, structural expansion and settling, so it's safe for use indoors and out.

PROBLEM #3: WIDE GAPS

For extra wide cracks and gaps that can't be sealed with a standard-width product, try durable, convenient Press-In-Place® Caulk for Wide Gaps.

PROBLEM #4: WINDOW GLAZING

Why hire a professional glazier when you can repair windows yourself with Press-In-Place® Window Glazing? Simply cut the pre-shaped glazing to the correct length, press into place, strip off the plastic liner and smooth with your finger.

PROBLEM #5: ROOFS AND GUTTERS

Repair dozens of rooftop and other outdoor problems, including sealing such installations as vents, fans, air conditioners and gutters with Press-In-Place® Roof & Gutter Caulk.

For more information, contact
**Customer Inquiry, DIY Division,
3M Center, Bldg. 223-4S-01
St. Paul, MN 55144**

What's News *Continued*

Sarich's Orbital Engine Co. of Perth, Australia, recently announced that it has purchased a plant in Tecumseh, Mich., to produce the compact two-stroke. The plant will have a production capacity of 250,000 engines per year. The initial run will be used for outboards. Sarich hopes to begin selling two-strokes for autos in 1993. Ford and General Motors have already signed licensing agreements.

Heavy rains affect planes

New NASA studies indicate that heavy rains may reduce aircraft wing performance during landing approach or take-off maneuvers—when such performance is most required. NASA says that its findings may require pilots to adjust for the effect of heavy rain when they are landing and taking off. The NASA tests raise the possibility that heavy rain disrupts the airflow across the wing. This reduces wing lift and performance. The tests were conducted at the Langley Research Center in Hampton, Va.

Vegetation and weather

A concerted international effort using space satellites, aircraft, and automatic meteorological stations began this past summer to learn how the planet's vegetation affects weather, and eventually climate.

The study, called FIFE '89, is coordinated by the Laboratory for Terrestrial Physics at NASA's Goddard Space Flight Center. It involves scientists from the United States, Russia, Canada, England, and France. With the help of data from five remote-sensing satellites, six research aircraft, and dozens of sophisticated surface and airborne measurement devices, the group conducted intensive observations of an 81-square-mile swatch of central Kansas prairie grassland to learn how surface vegetation regulates the rate of soil moisture evaporation to the atmosphere.

Scientists studying the effects of global warming believe that such a control process could actually intensify droughts: When a dry period drops the soil moisture level below a given threshold, vegetation could limit evaporation enough to deprive the lower atmosphere of the ability to form rain-producing clouds.

Herbert Shulder
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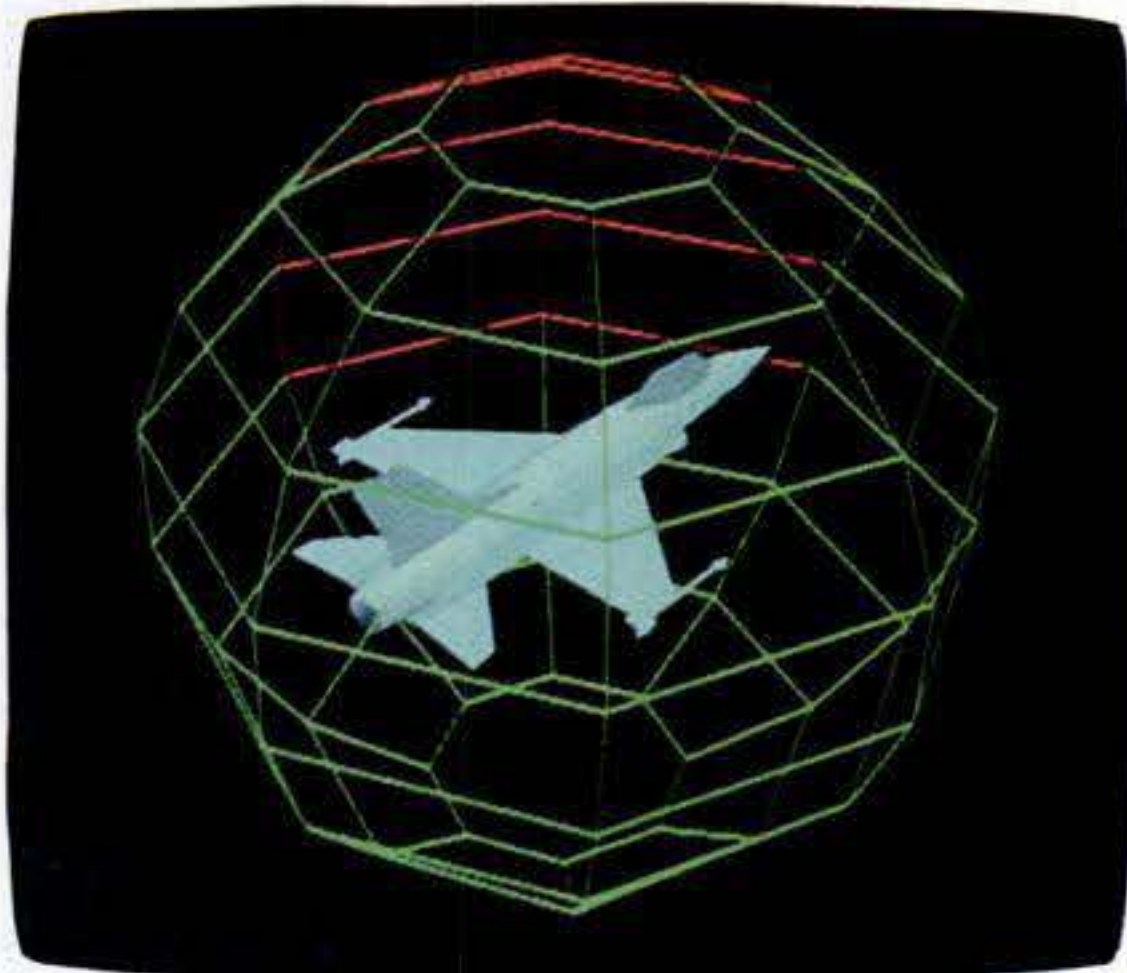
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PERHAPS YOUR FUTURE'S UP IN THE AIR. AND YOU JUST DON'T KNOW IT



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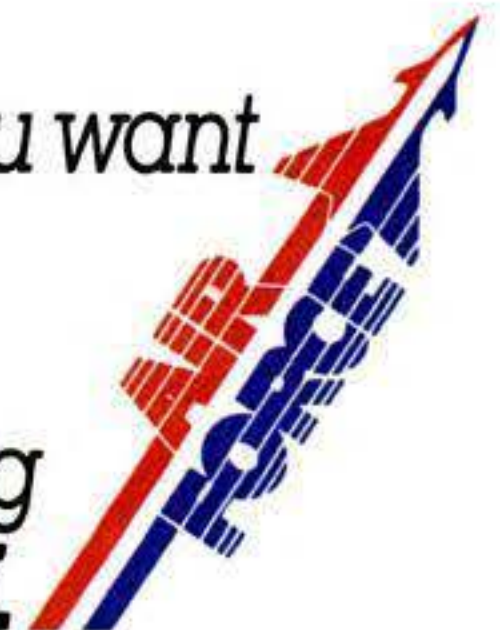


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Readers Talk Back

Hot topic

Regarding the series on global warming: I hope that the August POPULAR SCIENCE reflects an editorial change that will continue to present issues that are of concern to all. We are leaving a legacy of destruction for our children, all in the name of progress!

Ross Binnie
Kearney, Ontario, Canada

The greenhouse and gas

In the words of an Okefenokee Swamp resident, we have met the enemy, and they are us. Though autos are a primary culprit of environmental problems ["What's News," Aug.], changing attitudes about private vehicles is quite an undertaking: Americans seem to be born with an ignition key in their fists, and much of our industrial economy is tied to automobiles and related fields.

Charles A. Hand Jr.
Charleston, S.C.

Your expressed concern with environmental issues and conservation is at odds with articles such as "Turbo To Go" (same issue), with Shelby cars that get only 17 and 25, and 20 and 28 city and highway mpg, respectively. How about some consistency?

Larry Miles, Independence, Mo.

Why is it that whenever something is wrong with the atmosphere, it's always the problem of larger, *safer* cars? I've been in two accidents while driving small fuel-efficient cars from Japan, but now I drive a Chevrolet Caprice because I want a safe car for my family. My suggestion? Raise the gas tax and improve public transportation with the money.

Perry J. Kravec
Bethel Park, Pa.

Politicians and bureaucrats are largely responsible for the failure to support efficient-energy programs. In response to President Carter's call to save energy, I bought a small diesel Volkswagen. A tax on diesel was immediately levied, and its cost escalated above that of regular gasoline. Diesel

cars are now few and far between.

Merdin Criddle, Aptos, Calif.

Your editorial brought to mind an article by S. Fred Singer in the June 30 *National Review*. Singer, a professor of environmental sciences at the University of Virginia, has served as director of the U.S. weather-satellite program, deputy assistant administrator of the EPA, and chief scientist of the Department of Transportation. To oversimplify his position, there may well be a problem with global warming, but available data are so inconclusive about cause or cure as to be meaningless. He points out that no one really knows whether fluorocarbons or burned hydrocarbons are having any significant effect, and if so, what that effect is.

Willard B. Tribble, Fair Oaks, Calif.

Timely article

Thank you for a most interesting piece on Stephen Hawking [Aug.]; I hope readers take time to read *A Brief History of Time*. Although it is not a human-interest book, it is an insightful theory of the universe that deserves a good, hard look. As for the imaginary time that Hawking feels he didn't address, think of it as the eighth day of the week; it's there—just cross your eyes and look between Sunday and Monday!

The Rev. Taras Chubenko
Carteret, N.J.

Tool warnings

Flomatic has recalled the Cool Tool, a gas-operated tool that freezes pipes shut to ease plumbing modifications. The tool, which appeared in the December 1973 issue on page 90, uses Freon 22, an odorless, colorless gas that is toxic if inhaled. Flomatic is offering a full refund, plus 20 percent, for any tools or components returned. Timothy Jansen, general sales manager

Flomatic Corp., Box 100
North Hoosick, N.Y. 12133-0100

We are concerned about an advertisement in your June issue. In the ad, someone appears to be grinding corrosion or paint off a natural gas meter with a Dremel Cordless Moto-Tool. This is potentially dangerous. If there were even a minor gas leak, a spark

from the tool's motor—or that of any other sanding or grinding tool—could cause an explosion or flashback.

Frank Mansell
Northwestern Utilities Ltd.
Edmonton, Alberta, Canada

Readers bark back

Whose pea-brained idea was it to put "RTB" in the back pages? I want to see readers' criticism first, especially as it relates to subjective preference.

D. Sill, Monroe, Iowa

Please restore "RTB" to its rightful place at the beginning of the magazine. It's the first thing that I (and I suspect many subscribers) read. I know it's not a big deal to flip back to find it, but it seems shabby to put our comments last. The only publications that I know of that put letters in the back are newspapers—and they at least put them in an important area, across from the editorials.

Michael Morse, Garrett Park, Md.

Cool thinking

One thing you didn't mention in the April article "Ice Power": How is the ice converted back to water for the next trip on Icy Rider? Also, the inventor might try using a refrigerant instead of water to increase the vehicle's driving range. A refrigerant would vaporize from solar heat during the day and liquefy at night. This way, the process could run in reverse at night, using the vacuum created by condensing vapor for the added driving range.

Lloyd T. Chambers Jr., Salisbury, N.C.

Used frozen water cylinders are stored indoors during the day to thaw, and then refilled with oil. At night, the canisters are moved outdoors to freeze for the next day's driving. Inventor Bo Nordell should be interested in your refrigerant idea.—David Scott

Corrections: J&J Trading, listed as a rubber-recycling company in "Technology Comes Home" [Aug.], has changed its name to Recycled Tire Products Corp., One Briar Dr., Kelton, Pa. 19346.

The volume of the storage cavern in "Compressed-Air Power" [Aug.] should have read 19 million *cubic* feet.



Lux One-Fam, 138 Cu Ft, W/W Carpet, Magnif Liv Spce, 4-Drs, Hi Ceil, Easy Commute City/Shppg/Wilderness. New.

It's good to find something that rewards your investment as handsomely as the new Montero.

Consider it just as a 4x4: automatic-locking hubs, 4-wheel drive, and a 3.0-liter, 143 hp, V-6 powerplant are all standard. They let Montero take you out where the *Grt Vus* are.

In comfort. "Off-road, the Montero handled the rough with grace," reported *Motor Trend*, "courtesy of its independent suspension with unequal-length A-arms, torsion bars, and anti-roll bar in front and solid axle with coil springs in back."

But there's no sense in achieving such comfort and control off-road, only to feel sorely out of place on the highway. So the Montero's sophisticated suspension system is designed

to be smooth-riding on the paved roads.

Add the fact that the 4-door Montero provides nearly a third more interior cargo space than Jeep Cherokee or Isuzu Trooper II, and you'll see why *Motor Trend* ultimately chose it Top Buy in the Sport/Utility Class for 1989.

All this, and so *Vry Rsuably Prcd* at only \$17,099*.

Call 1-800-447-4700 for your nearest Mitsubishi Motors dealer.

*Mfr's sugg. retail price. Actual price set by dlr. Tax, lic., freight, dlr. options and charges extra. (Montero shown with optional alloy wheels—M.S.R.P. \$464.)

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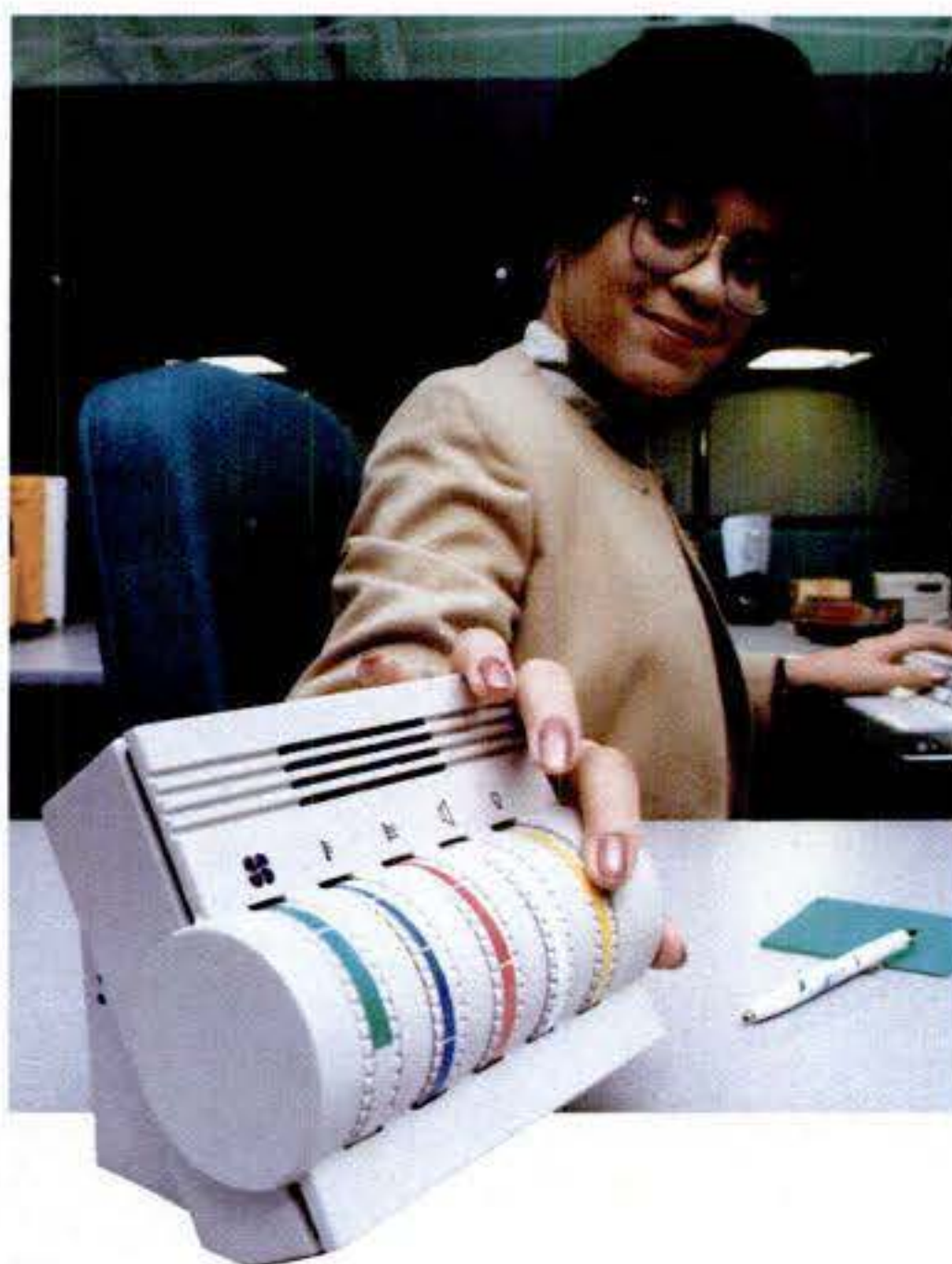
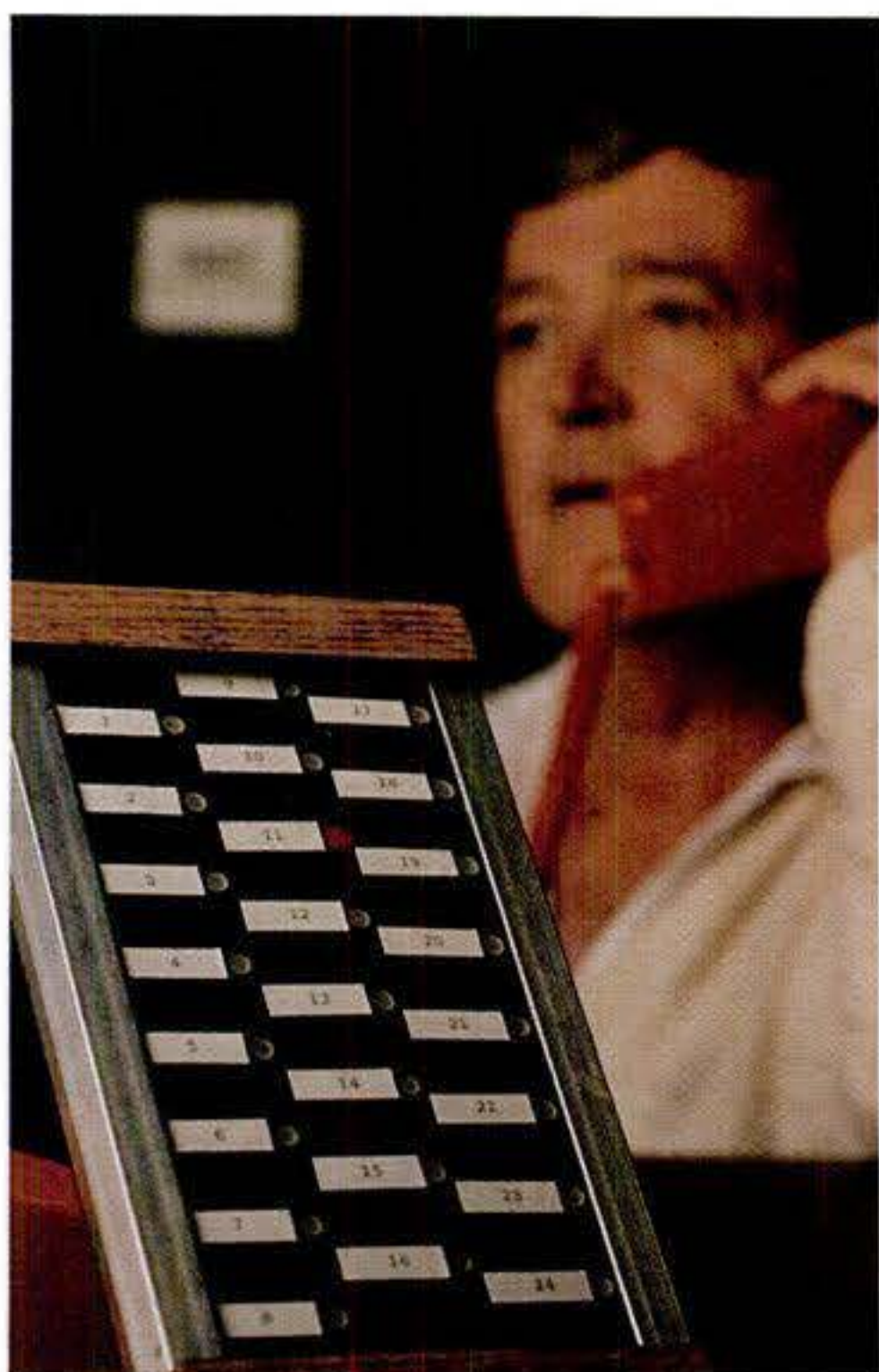
Seagram's
V.O.

MY SON HAS A SON. TONIGHT WE DRINK GOLD.

What's New

Customized cubicle ►

Personal Environment Modules designed by Johnson Controls of Milwaukee allow office workers to adjust lighting, temperature, and airflow levels at individual work stations. Motion sensors turn everything down while you are away from your desk.



Compass on a card ▼

This compass floats on a puddle or a capful of water. Smaller than a dime, it comes attached to a set of waterproof cards listing survival instructions. The Life Card set, which fits easily into a wallet, also has a flat magnifying lens for starting fires. Brunton U.S.A., 620 E. Monroe Ave., Riverton, Wyo. 82501.



◀ Help phone

Elevator phones often require callers to speak or dial a number for emergency assistance. U.S. Com-Trac's LOTEL eliminates multiple lines and identifies a phone's location when it is lifted off the hook.



◀ Centaur stage

Inside General Dynamics Space Systems Division's building, the upper stage of the Centaur heads for its assembly dock. Paired with the Atlas booster, the Centaur is to launch a Navy satellite this fall.

Super spinner ▲

Equipped with motion detectors, Haven-Busch Co.'s oversize Cirkel-Line revolving door accommodates wheelchairs, and matches the speed of the slowest user. With the motor off, door panels open on hinges.

What's New

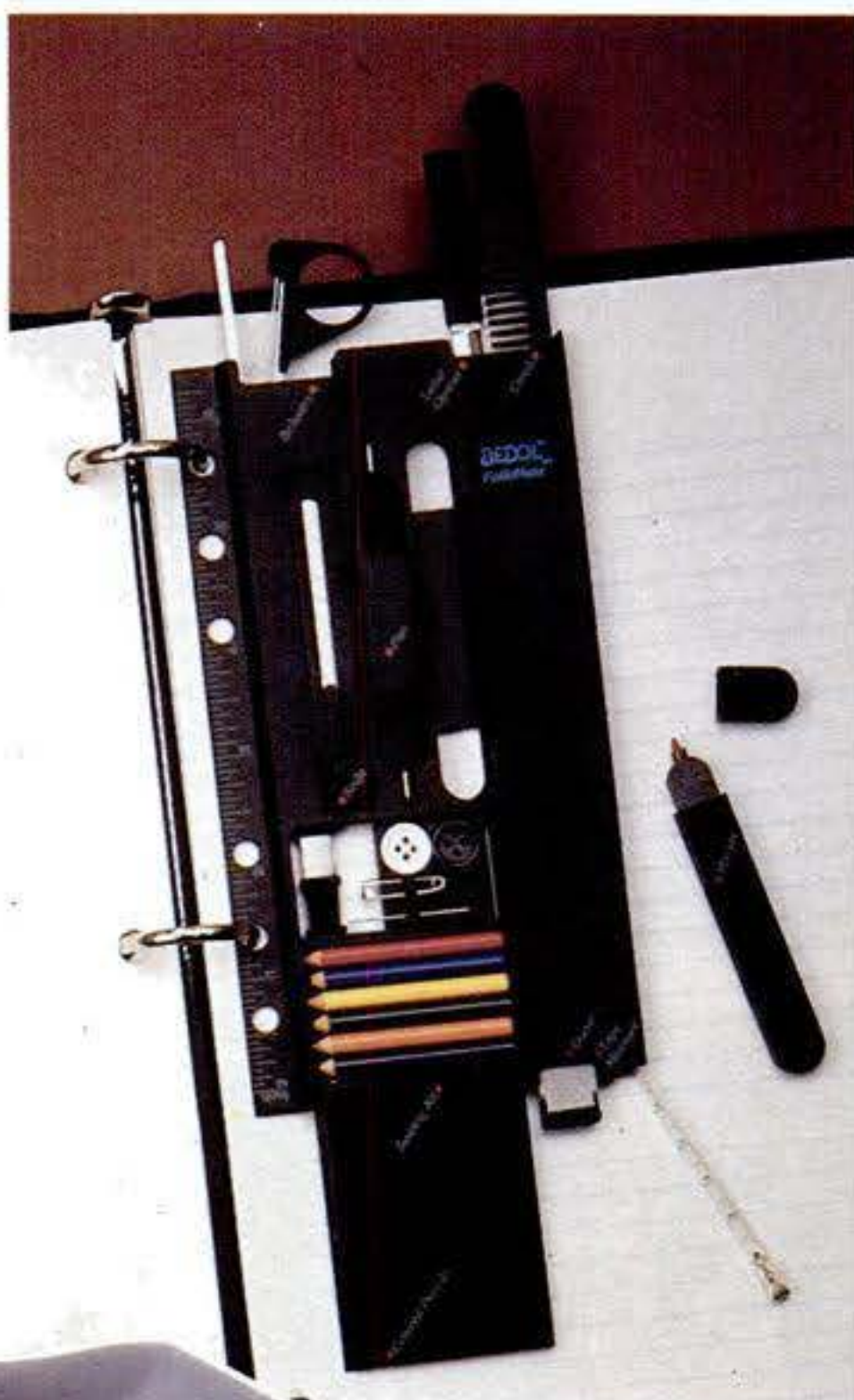


Bye-bye birdies ▲

At Ben Gurion International Airport in Israel, this remote-controlled aircraft fires harmless pyrotechnic devices at birds, chasing them from the area so they can't interfere with air traffic. Air Birdstrike Prevention of Worcester, Mass., says the birds, mostly seagulls, quickly adjust to more traditional devices.

Mini office ►

Less than 1/4 inch thick, the Folio-mate (\$25) clips into a notebook binder. It carries supplies such as pencils, scissors, and a letter opener. From Bedol International Group (1768 Fillmore Dr., Monterey Park, Calif. 91754).



◀ Close-up views

Unlike most "no-focus" binoculars, which can't focus on objects closer than 40 feet, Bushnell's 7x35mm Spectator-Plus models have a close-up setting. Touch two buttons, and the \$129 binoculars focus down to about 15 feet.



"Tallest tower" title fight ▲

The proposed Miglin-Beitler Building, supported by a cruciform concrete tube, would be almost 400 feet taller than the Sears Tower (left), the world's record-holder since 1974. If Chicago approves plans for the slender 125-story office complex, construction could begin next month. But Sears may retaliate by adding another 16 floors to its 110-story skyscraper, which was up for sale as this went to press.

The BBC Language Course for Children Only Seven Years Old*... and She's Already Speaking French!

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In French,
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German!

It's a scientific fact...and one of Nature's marvels. During the early years of childhood, the human mind is best programmed for learning a language — any language.

That's why children learn so much more easily than adults, even *before* being able to read. They learn the same way they learned English — naturally — by listening, seeing, and imitating. In the international world our children will compete in — where so many Europeans and Asians start a foreign language early — a second language will be essential. Vital for competing with polished and accomplished peers.

Sample ages for beginning a second language**

Japan	Age 8	France	Pre-School
Sweden	Age 7	Spain	Pre-School
Austria	Age 8	Canada	Pre-School

** Ages represent top schools and programs; compulsory language education usually begins several years later.

From the BBC, World Leaders in Language Education

For the first time ever in the U.S.A., your child can learn French, Spanish, Italian or German using the most successful Language Course for Children ever created!

Muzzy, a unique video learning program, is produced by the BBC — the world's foremost teachers of language. Specifically designed for children (pre-school through age 12), *Muzzy* uses color animation, enchanting songs, and charming, involving characters (including *Muzzy* himself), and teaches children to absorb a new language the same way they learned English.

It's so easy and so much fun. In fact, most kids love to watch or listen over and over again, just like their favorite TV shows!

Complete Language Learning Course!

Everything needed for a child to master beginning French, Spanish, Italian or German is included. Four video cassettes. Two audio cassettes. An activity book and an excellent parent's instruction guide plus answer book. All in attractive, durable storage cases.

Through *listen-and-learn* and *see-and-learn*, your child will begin speaking a foreign language from the very first day! He or she can learn alone, or you can help and learn the language, too!

No Risk Guarantee!

Here is perhaps the greatest gift you will ever give your child...a second language. And at an astonishingly affordable price of just \$145⁺, payable in four credit card installments. And there's no risk! If you and your child are not absolutely delighted, you may return the course within 30 days for a full refund. Order today from Early Advantage, 47 Richards Avenue, Norwalk, Conn. 06857.

†Plus \$4.75 shipping/handling per course.

Now
Available
for the
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in the
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By exclusive arrangement with the British Broadcasting Co.
A program proven with thousands of European youngsters.
And the whole family can learn the language, too!

* Proven results for pre-school through age 12.

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The BBC Language Course for Children

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Satisfaction
Guaranteed

For Fastest Service — Call Toll-Free: 1-800-367-4534

Yes! Please send me *The BBC Language Course(s) for Children* I have indicated. I understand only VHS format is available.

(Please check appropriate items.)

Language: ☐ FRENCH ☐ SPANISH ☐ ITALIAN ☐ GERMAN

Name _____

PLEASE PRINT CLEARLY

Address _____

City/State/Zip _____

Signature _____

(All orders subject to acceptance.)

Charge each of four monthly \$37.44* installments to my credit card:
☐ VISA ☐ MasterCard ☐ Diners Club ☐ American Express

Credit Card No. _____ Exp. _____
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☐ I prefer not to use my credit card and will pay by check. Enclosed is my deposit of \$50* for each course. I will pay the balance of \$99.75* as billed in three monthly installments.

*Includes one-time shipping/handling charge of \$4.75. CT residents add 8%; TN residents add 7-3/4% sales tax. Allow 2 to 4 weeks for shipment (4 to 6 weeks for German).

372-8479

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What's New ELECTRONICS

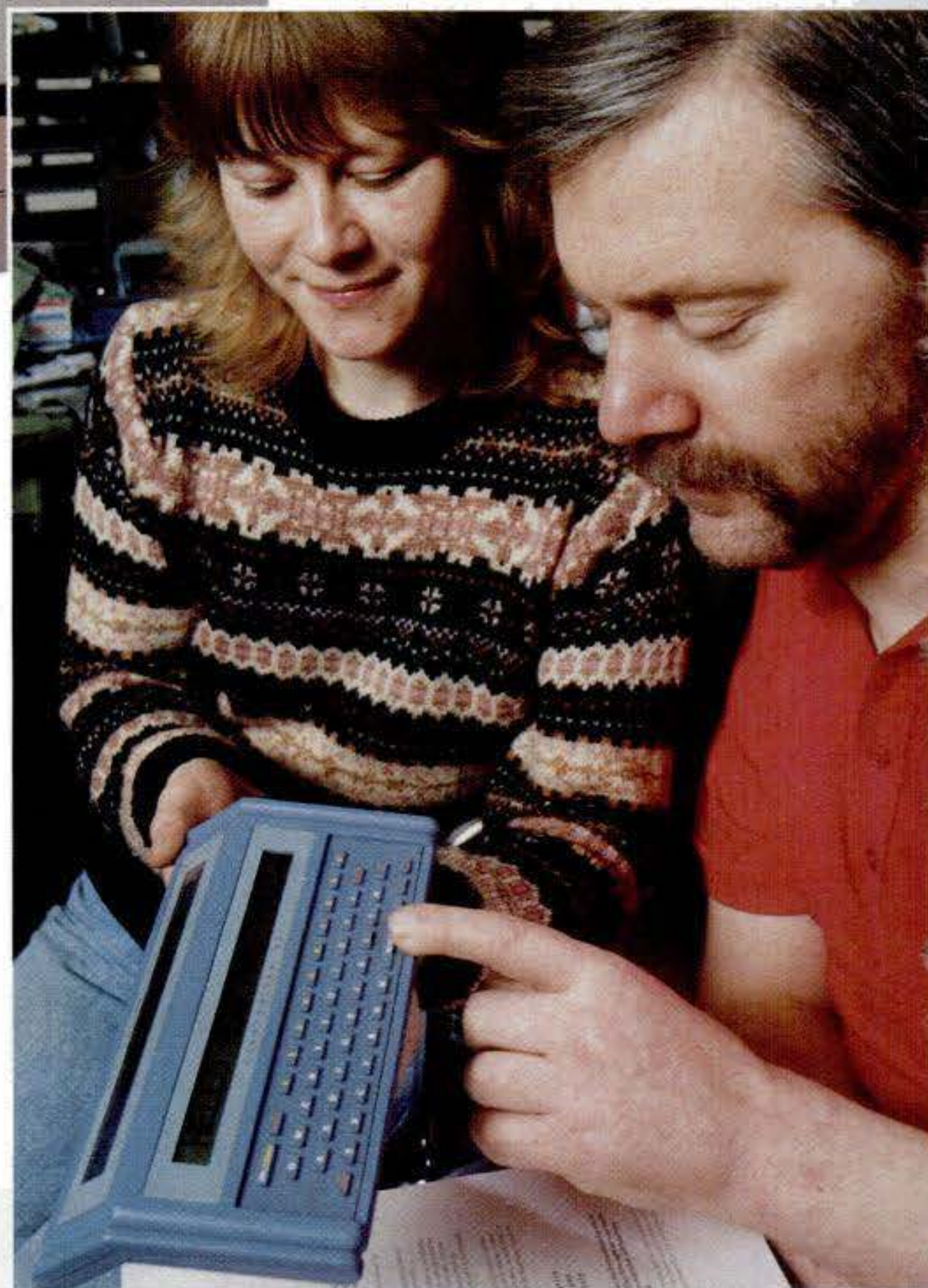


◀ Make it neat

Stow the keyboard in the Space-Saver when you're through computing. The case is handsome, yet tough enough to support both the computer and its display. Non-slip padded feet prevent the high-impact plastic from scratching the work surface. It's \$40 from Curtis Manufacturing Co. (30 Fitzgerald Dr., Jaffrey, N.H. 03452).

Lofty idea ▶

Hold up the pocket-size Air Velocity Indicator, and its LCD shows wind speed in mph, knots, feet per minute, or meters per second. It's used for everything from boating to crop-dusting, according to the maker, Omega Engineering (1 Omega Dr., Stamford, Conn. 06907). It's \$99.



Flip-over player ▶

The LCD display on Pioneer's CLD-3070 CD/CDV/LD player isn't just handsome—it's informative too. It's got to be. Reason: The machine can play either side of a videodisc without your having to turn it over manually. How? Inside, a special laser head tracks one side of the disc then flips over to track the other. Price: \$1,200.



Communicator ▲

Type on the Lightwriter, and the words appear on the front and rear LCD displays. Result: People with hearing or speaking impairments can easily communicate with one another. Winner of the 1989 British Design Award, it's made by Toby Churchill Ltd., 20 Pantons St., Cambridge, CB2 1HP, England.



◀ Fake finder

Rub any paper currency with the Vistatec. If the bill is good, you hear a tone, and a green LED lights. But if no magnetic particles are detected in the ink, the bill is deemed counterfeit, and the detector's red LED warns you. It costs \$100 in real money from Vista-tech Enterprises, Ltd., 935 Broadway, New York, N.Y. 10010.



"STOCK UP ON AC FILTERS AND PLUGS AND SAVE AS MUCH AS \$8.80."

— Chuck Yeager

Now's the time to get your car running right without emptying your wallet. With money-back offers on AC Spark Plugs, Air and Oil Filters.

The copper-cored electrodes in AC plugs dissipate heat and resist fouling better than conventional electrodes. And between August 23 and November 5, get back 35¢ on each plug (limit eight).

During this time you can also save \$1.25 on each AC Oil Filter (limit two) and \$1.75 on AC Air Filters (limit two). AC Oil Filters are designed to protect gasoline engines for up to 15,000 miles and AC Air Filters for up to 30,000 miles. Check your owner's manual for your car's recommended change intervals.

For a nearby AC-Delco retailer with rebate details, just give me a call at 1-800-AC-DELCO.



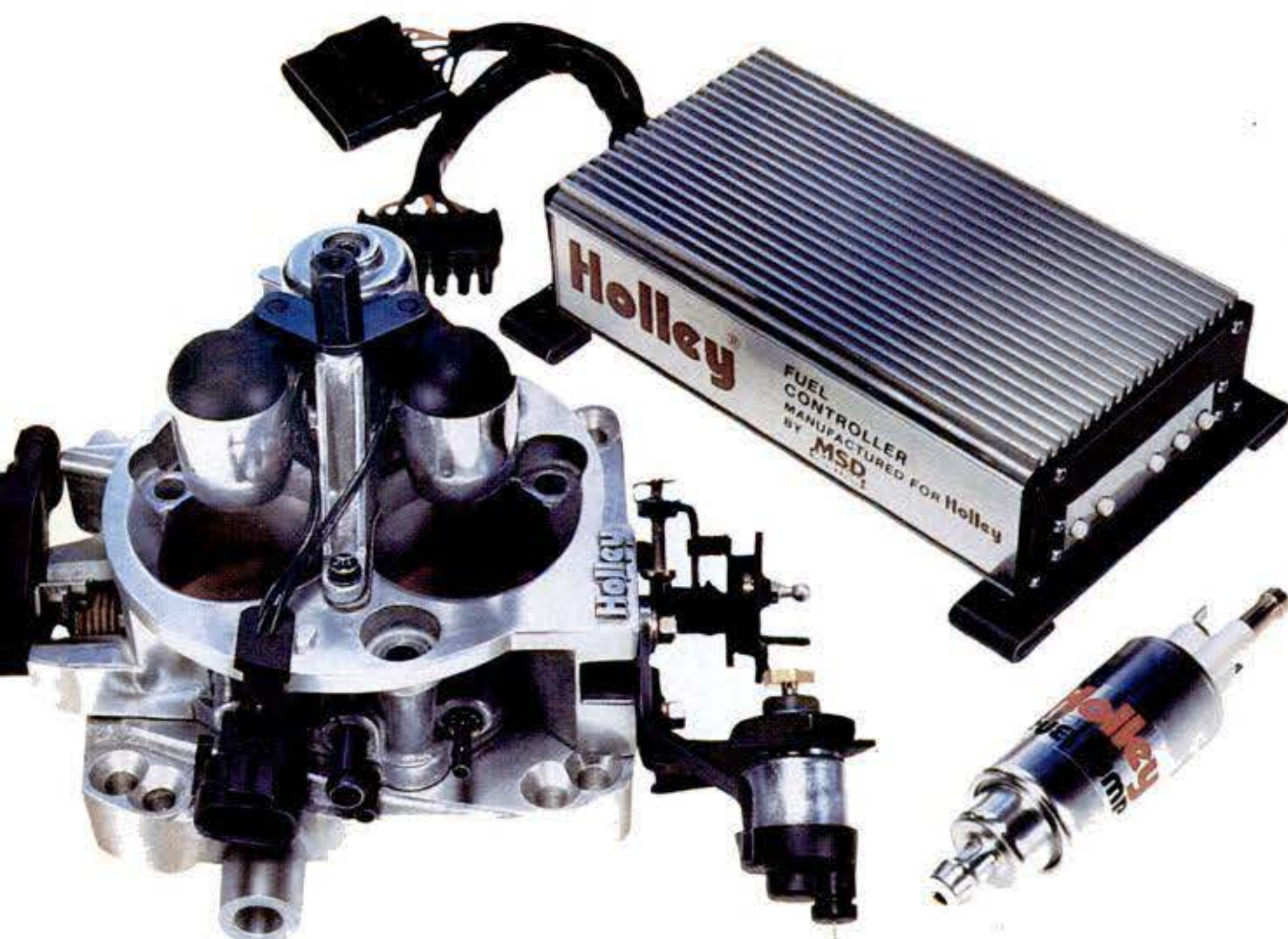
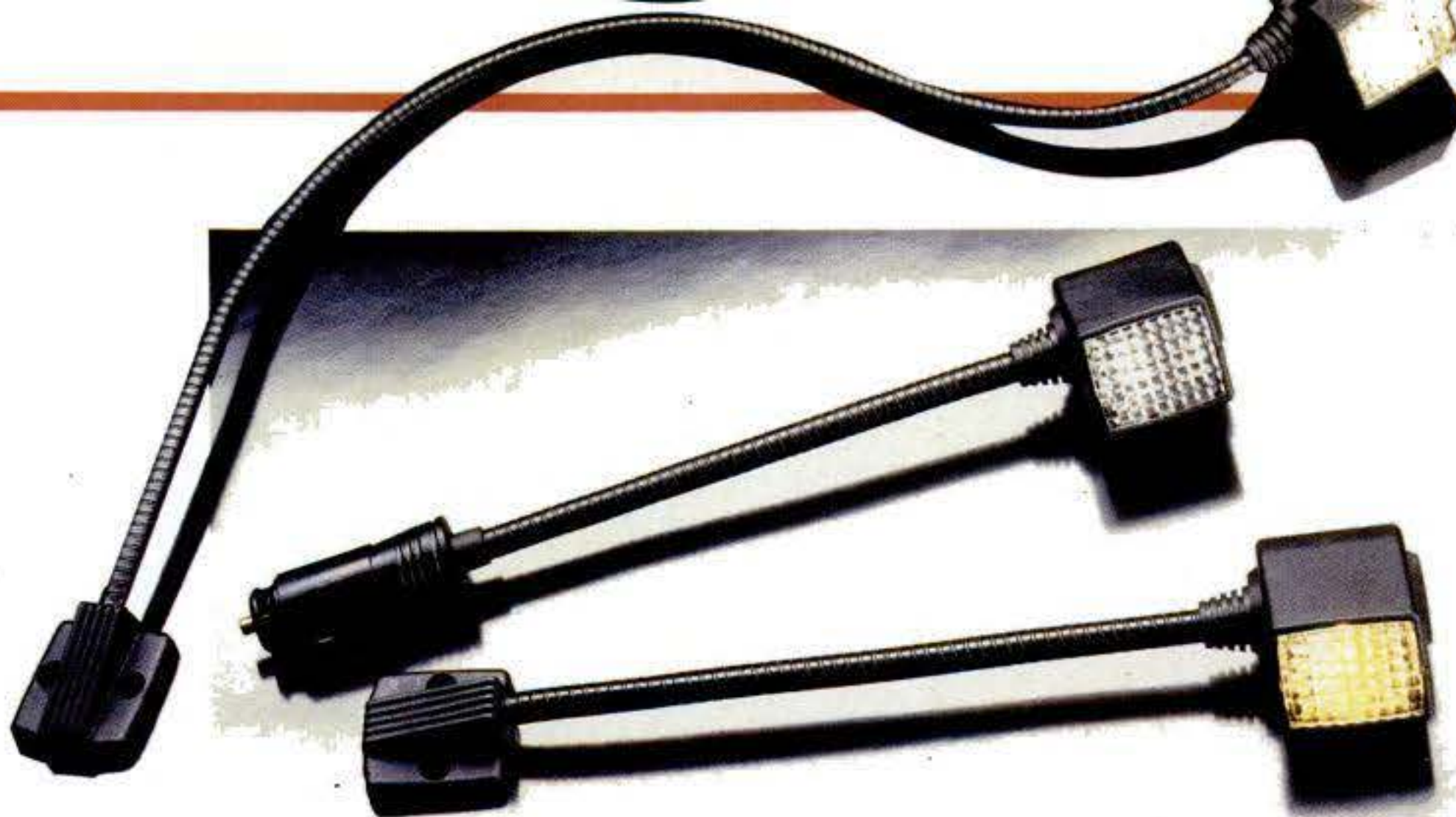
GENERAL MOTORS CORPORATION

AC-DELCO. THEY DON'T JUST FIT. THEY MATCH.

What's New CARS

Flex lights ▶

Powerful halogen lamps on flexible stalks can illuminate maps and directions without diverting the driver's attention. With lengths from 8 to 20 inches, these lights made by Hella of West Germany are powered by the car's battery via the cigarette-lighter outlet.



Fuel-injection retrofit ▲

The Pro-Jection throttle-body fuel-injection system replaces carburetors on non-computer-controlled V8 engines for improved fuel economy and performance, says Holley Replacement Parts Division. The suggested price is about \$900, depending on engine.



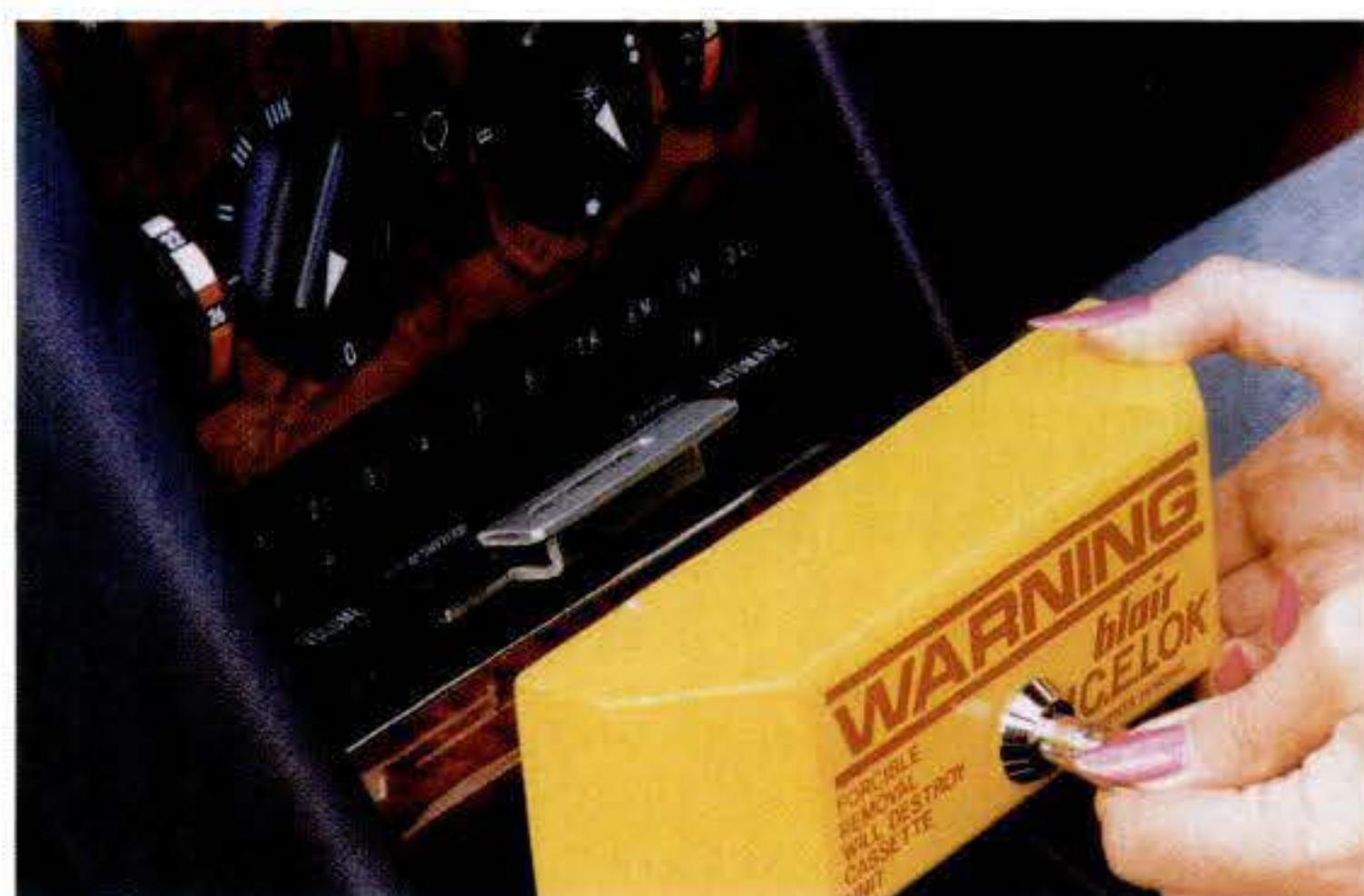
◀ Better seal

This P-shaped oil-filter gasket seal prevents over-tightening better than traditional flat gaskets, claims Wix Corp. (Box 1967, Gastonia, N.C. 28052). The replacement filter is available for most Japanese cars and light trucks.



Tuneup tools ▲

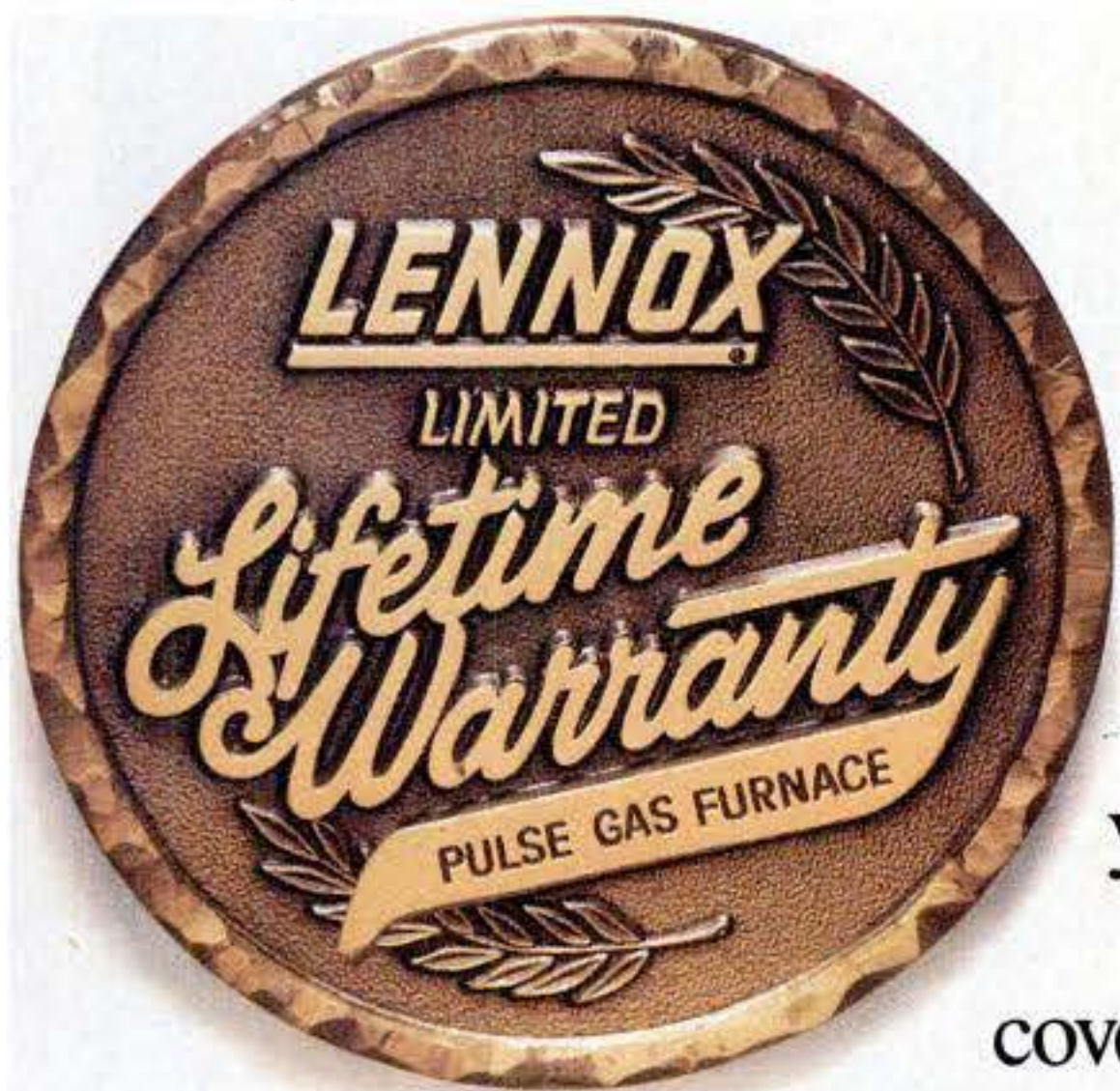
This set of three test instruments contains the gauges you'll need to tune and adjust your car's engine. The compression gauge, multimeter, and timing light all fit into the set's carrying case. Optilux, 42 Jackson Dr., Cranford, N.J. 07016. Suggested price: \$130.



Cassette-player lock ▲

This steel stereo cover fits into a car's cassette player and securely locks to deter theft. Installation and removal takes seconds, says Blair Electrical Engineering Co., Clayton-le-Moors Industrial Park, Accrington, BB5 5JU, England.

If nothing lasts forever, would you settle for a lifetime?



The first Pulse™ gas furnaces were installed in 1981 and have established a remarkable performance record. That's why Lennox increased the Pulse heat exchanger warranty from 20 years to as long as you own the furnace*.

Lennox even made the warranty retroactive to cover every Pulse residential furnace ever sold. That certainly shows their confidence in the Pulse's reliability.

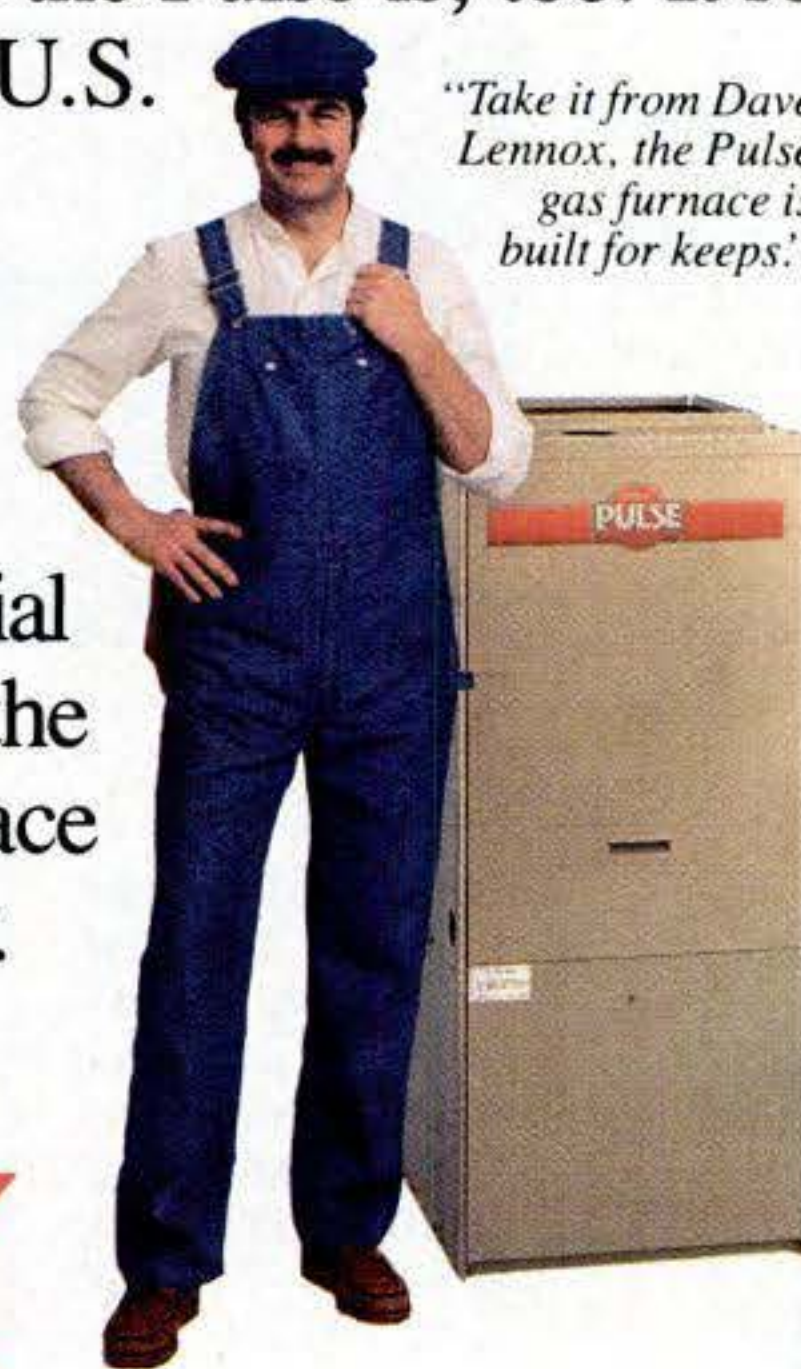
Others have discovered how good the Pulse is, too. It received a Special Award for Energy Innovation from the U.S. Government. It has earned the Good Housekeeping Seal. And the accolades of hundreds of thousands of homeowners from coast to coast.

If you would like to enjoy the special warmth only gas heat can deliver, plus the lifetime of energy savings a Pulse furnace can deliver, contact your Lennox dealer.

You'll live happily ever after.

LENNOX®

*Covers replacement of heat exchanger parts and applies to original buyer.



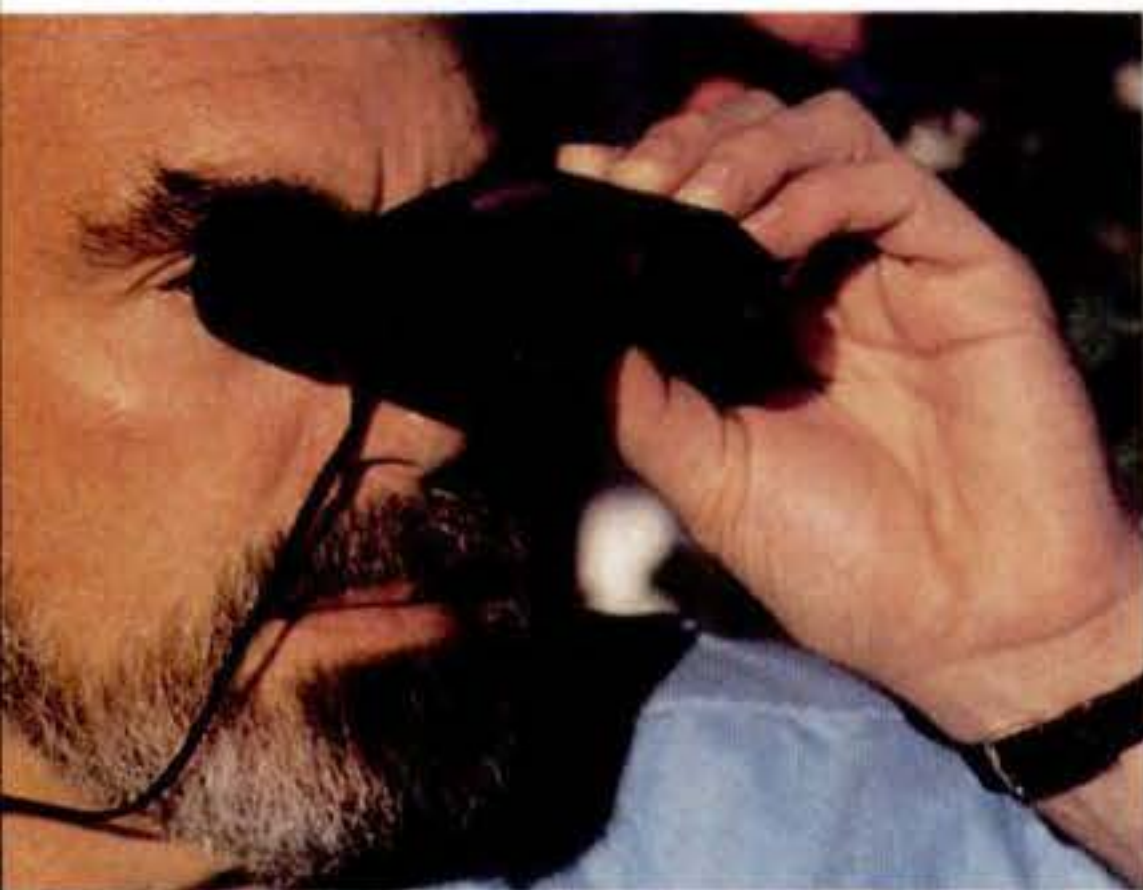
"Take it from Dave Lennox, the Pulse gas furnace is built for keeps."



Gas. America's best energy value.
© 1989 American Gas Association

For comfort you
can afford, choose gas—
America's favorite way to heat.

What's New RECREATION



No focusing ▲

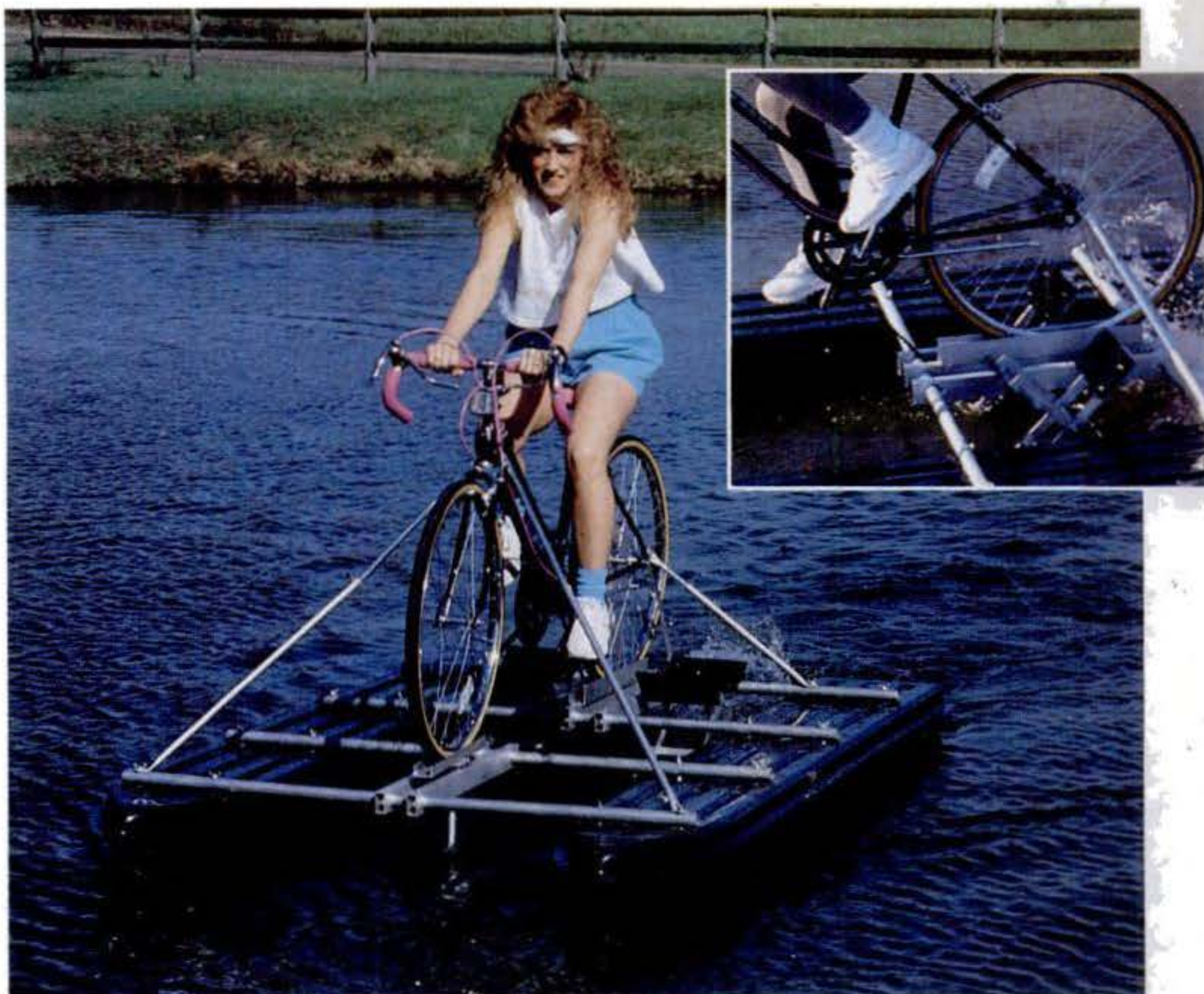
The optics in the Jason Perma Focus 2000 binoculars form an infinite depth of field, allowing the viewer's eye to define and focus on objects from 40 feet to infinity, says Jason Empire Inc. (Box 14930, Overland Park, Kan. 66214). This 7x power model costs \$129.

Automated table tennis ►

Interested in a robot that returns shots with a mean backspin? Hammacher Schlemmer & Co. (147 E. 57th St., New York, N.Y. 10022) has one for \$299.

Suited for the road ▼

The Aerostich Gore-tex motorcycling suit keeps out rain, is comfortable across a wide temperature range, and provides abrasion protection. Critical areas are reinforced with "ballistic" fabric and "visco-elastic" pads that stiffen on impact to absorb energy. Well-placed pockets, zippers, and reflective patches abound. Rider WearHouse, 8 S. 18th Ave. W., Duluth, Minn. 55806; \$467.



Catamabike ▲

Strap your bicycle onto this seven-foot catamaran, and you're ready to pedal on the water. A pair of paddle wheels driven by the rear tire provides propulsion, while a rudder lets you steer with the bike's handlebars. The 70-pound catamaran's ABS plastic pontoons and aluminum frame give a stable ride, says Herit Marine Design (134 Garfield Ave., Butler, Pa. 16001). Price: \$750 plus shipping.



It folds ►

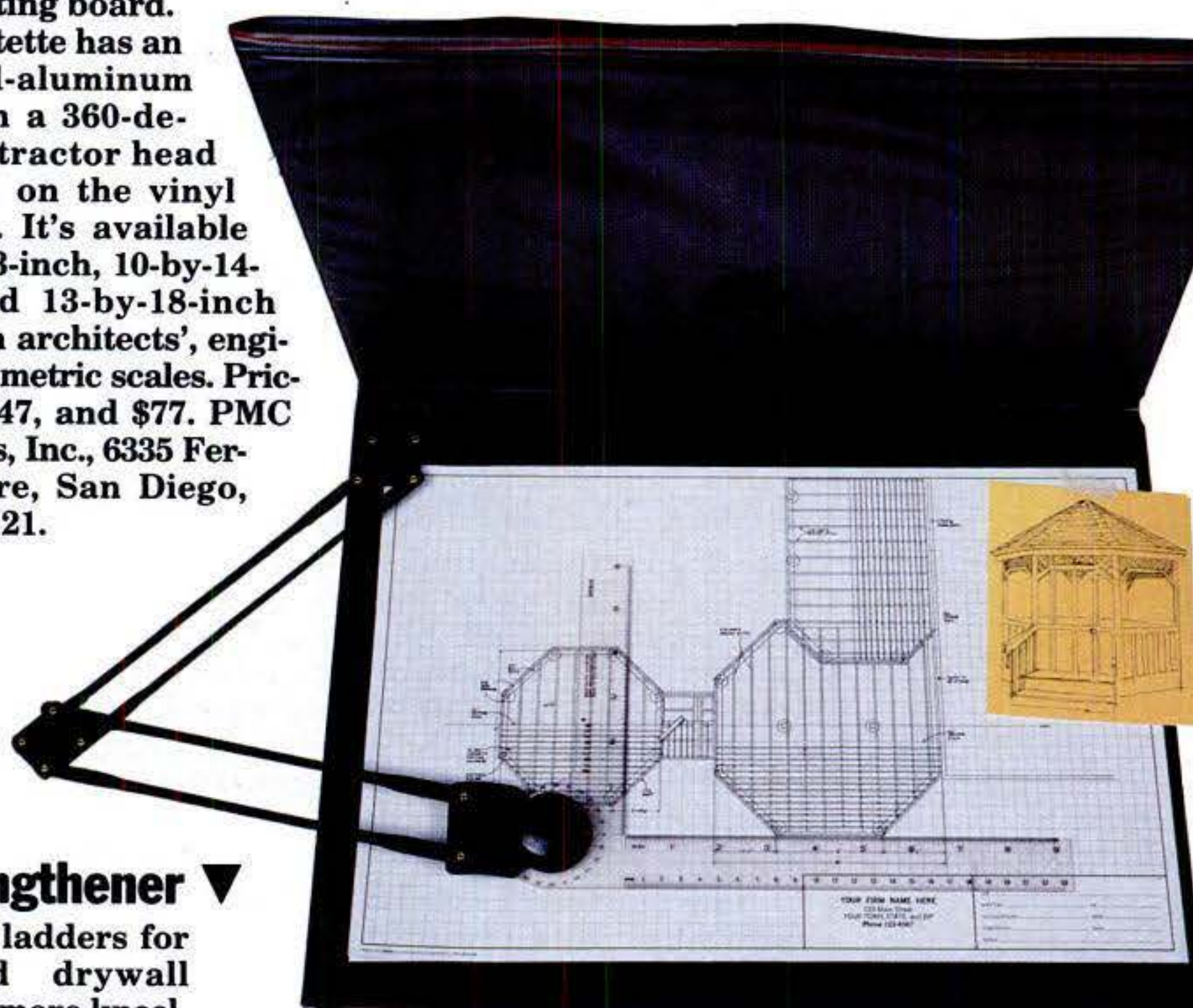
Most small-wheel folding bikes have been unstable disappointments. The Montague BiFrame has full-sized 26-inch wheels that make it a capable city bike. Flipping two quick-release levers allows the 30-pound cycle to be folded or unfolded in seconds, according to Montague Corp., Box 1118, Cambridge, Mass. 02238. Price: about \$485.



What's New TOOLS

Have pad, will travel ▼

You can draw your plans at the job site—or anywhere else—with a portable drafting board. The Draftette has an anodized-aluminum arm with a 360-degree protractor head mounted on the vinyl portfolio. It's available in 9-by-13-inch, 10-by-14-inch, and 13-by-18-inch sizes with architects', engineers', or metric scales. Prices: \$42, \$47, and \$77. PMC Industries, Inc., 6335 Ferris Square, San Diego, Calif. 92121.



Arm lengthener ▼

No more ladders for overhead drywall work; no more kneeling when you work on a subfloor. Extend-A-Bit lengthens your screw gun in two-inch increments. Sections come two to a package; use as many as you like. Extend-A-Bit is \$20 a set. Goldblatt Tool Co., Box 2334, Kansas City, Kan. 66110.



Steamy news ►

Steamworks from Black & Decker is a portable steamer for wallpaper removal. You fill its 13.5-ounce tank with water, flip the switch, wait 60 seconds, then press a button: Steam loosens the adhesive, and you can scrape off the paper. A staffer who tried one says it's slower than a rental steamer but fine for small jobs. Price: \$50.



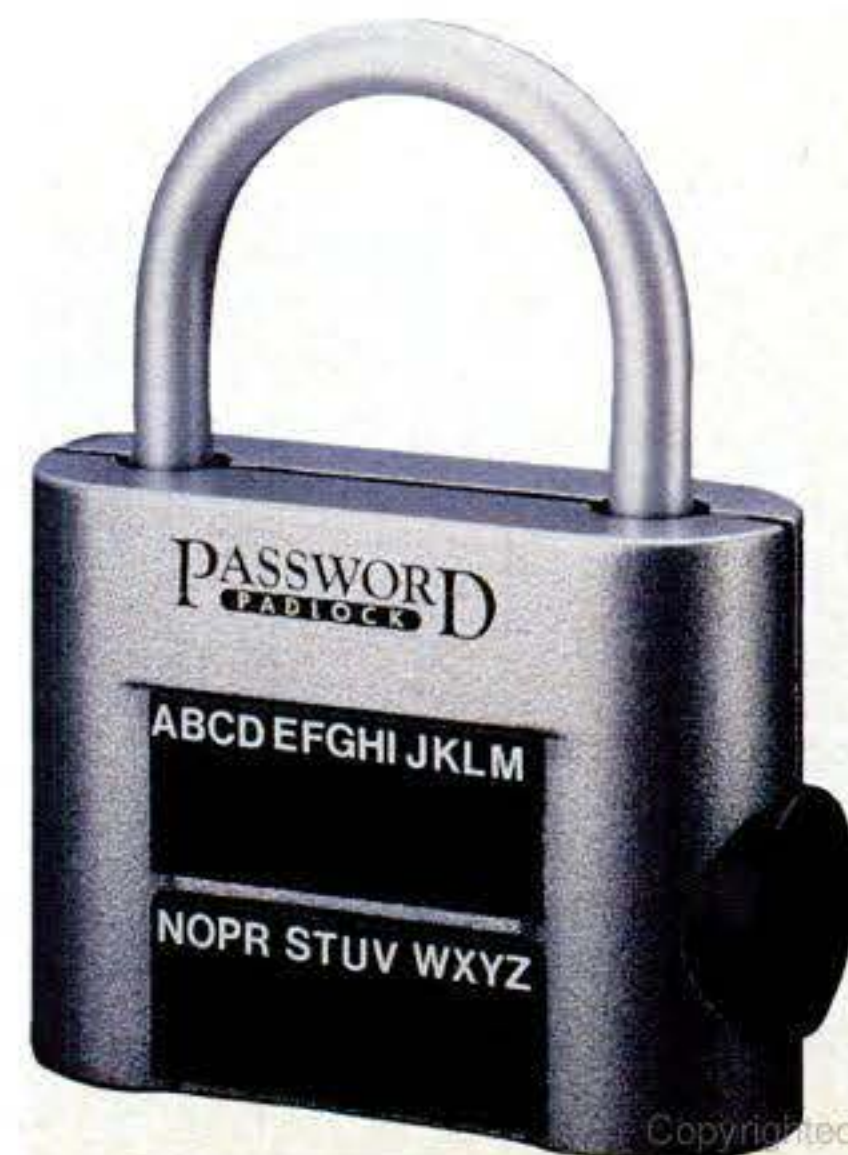
Grass cutter ▼

You can cut, melt, and seal synthetic-grass outdoor carpet in a single pass with Hot Tools' Model WB-1 knife. Its sharp tip reaches 850 degrees F. M.M. Newman Corp., Hot Tools Division, Box 615, Marblehead, Mass. 01945; \$20.



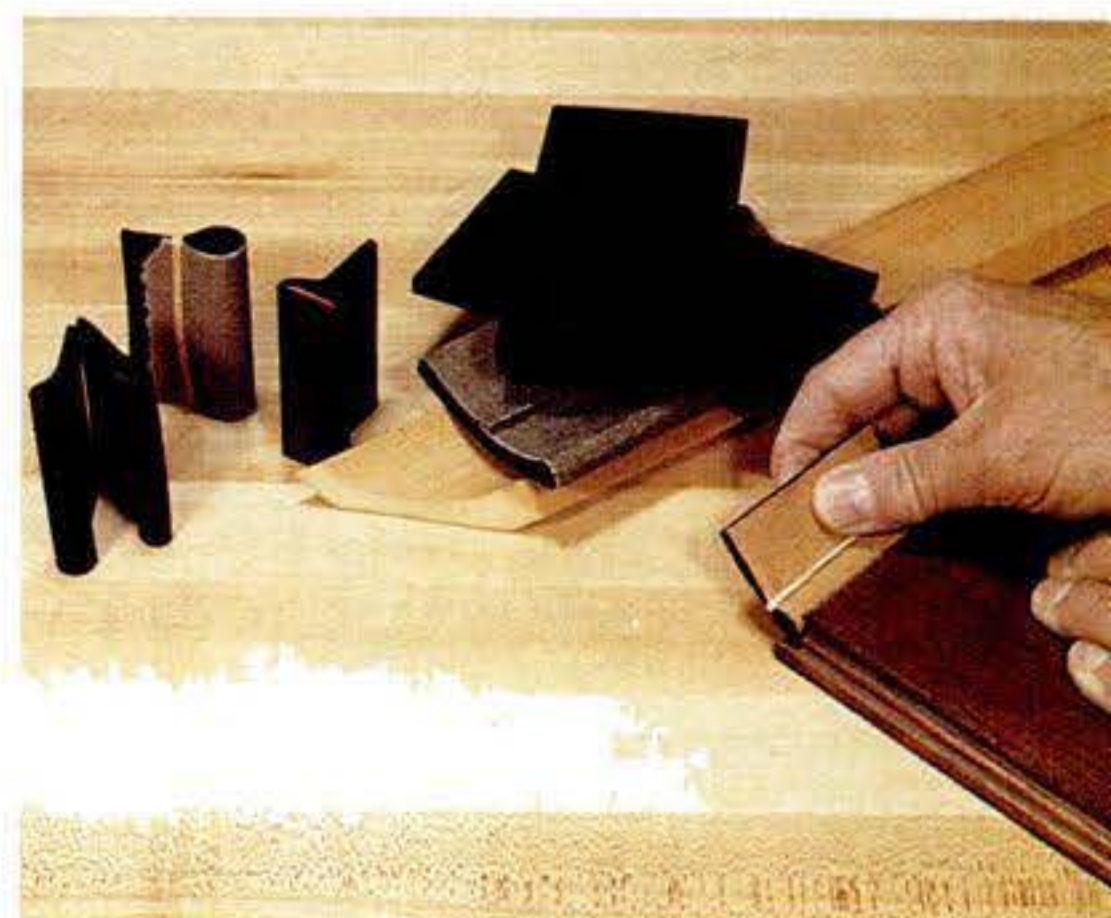
Literate lock ►

With the Password Padlock you don't have to remember numbers, just pick a word (up to six letters) instead. The \$15 lock, with metal casing and hasp, is easy to reprogram, says Homestar International (4473 Willow Rd., Suite 250, Pleasanton, Calif. 94566).

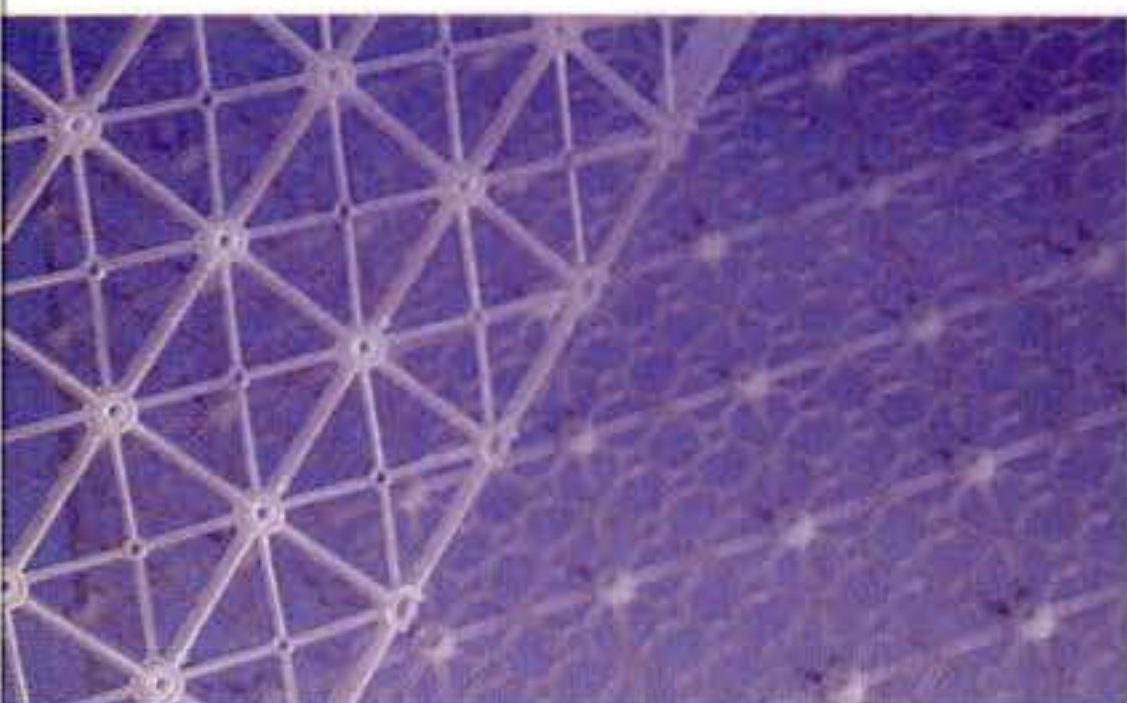


Soft sanders ▲

But not too soft. Two rubber pads flex for sanding curves, but the third is stiff enough for sanding edges. Five little sanding grips sneak into grooves and curves. The contour sanding set is \$5.50 from Woodcraft Supply Corp., Box 1686, Parkersburg, W. Va. 26101.

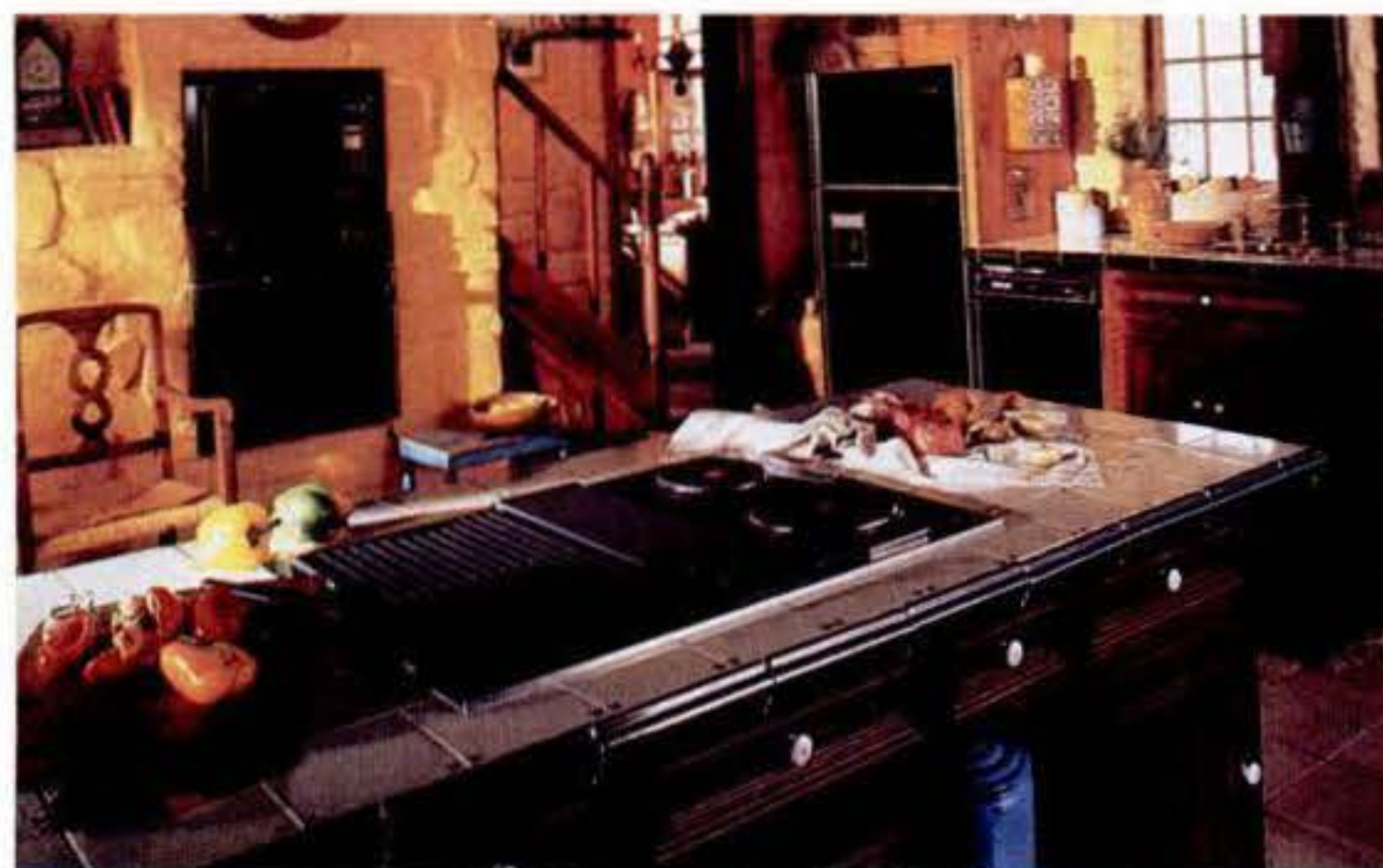


What's New HOME



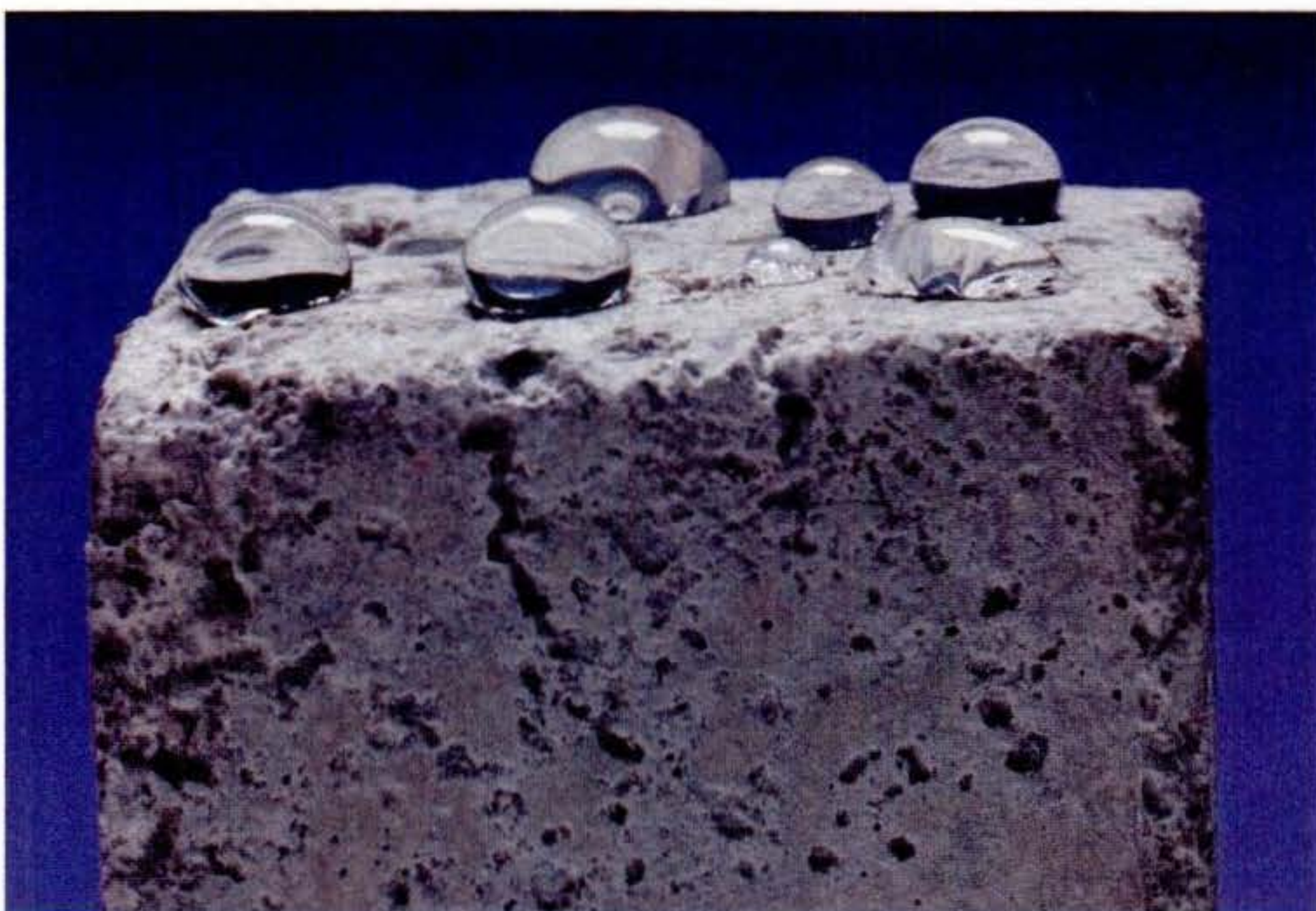
Plastic lath for tile ▲

Now you can install ceramic tile over almost any subfloor without fear of cracking grout or popped, cracked, or chipped tiles, says Laticrete International (1 Laticrete Park N., Bethany, Conn. 06525-3498). When filled with special mortar, the snap-together polyethylene Pro-Float grid forms a 1/4- or 1/2-inch-thick surface that "floats" over the subfloor and is high in flexural strength.



Super-remote ventilated cook top ▲

Most downdraft grill-range cook tops must be located near an outside wall for ventilation. Now Jenn-Air models, which have extra-large blowers, can be placed more than 50 feet from an outside wall, depending on ducting configuration. For locations closer than 30 feet, a removable restrictor ring decreases air movement to proper levels. Jenn-Air Co., 3035 Shadeland, Indianapolis, Ind. 46226-0901.



Waterproof concrete ▲

Those drops of water in the photo won't penetrate the concrete, but vapor trapped inside *can* escape to the atmosphere. GE Silicones' TWR 255 water repellent is a silane-modified polysiloxane, or silicone-based, coating. Due to its crystalline structure and cross-linking, or curing, characteristics, it resists liquid and chloride-ion penetration—eliminating efflorescence and salt damage—but remains permeable to moisture vapor, preventing scaling and spalling of concrete, says GE (Waterford, N.Y. 12188). Contractor applied only.



Day-to-night pleated shades ▲

Layered with colored fabric, an opaque middle layer, and white backing fabric, Nightfall pleated shades effectively darken rooms while preventing the shadows and silhouettes seen with other pleated shades, says Graber Industries (Middleton, Wis. 53562-1096). Price depends on window size.

◀ Extra-textured fiberglass shingles

With deep shadow lines and an extra-thick profile, Woodlands Premier roofing shingles simulate the look of wood shakes and last at least 35 years, says Manville (1601 23rd St., Denver, Colo. 80216). Heavy fiberglass matting and extra-large ceramic-coated granules add to durability and fire resistance. Price: \$59 per square (100 square feet).



Half the fun of owning it has nothing to do with driving it.

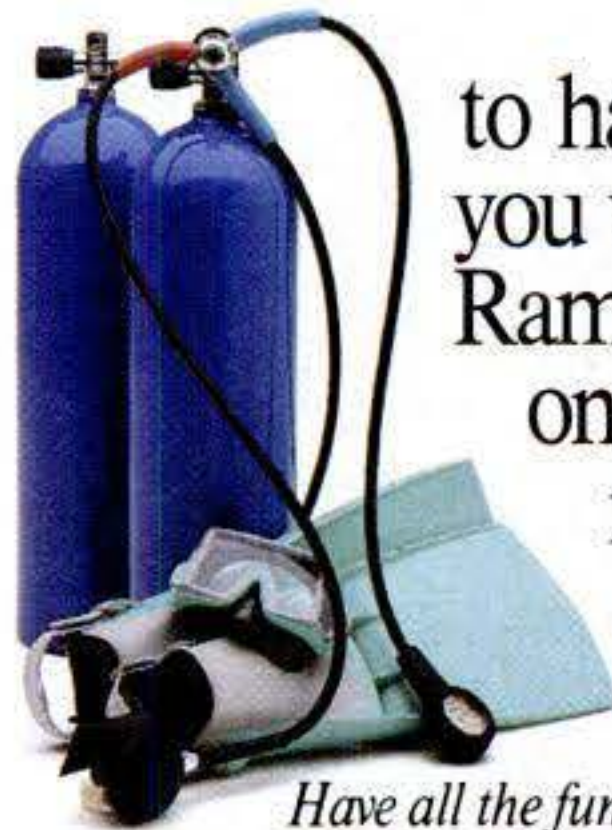
Not that we don't appreciate it, but you could be outside having a great time instead of sitting here reading a magazine.

If you had a Power Ram 50, for example, you could haul an ATV to the mountains and find out how long it takes to get mud in your tube socks. Or pack enough camping, scuba and fishing gear to rodeo from Death Valley to Tierra del Fuego.



Not that you have to go out of your way

You can take more tents in the bed than you'll own in your lifetime. As long as you fold them up first.



Have all the fun you want underwater. Just leave the truck on the shore.

your average midget bulldozer.

Which, despite all this snappy prose, is a lot more fun to do than read about.

The tough new spirit of Dodge.



to have a good time. Unless you want to. Because Power Ram 50 is very comfortable on cross-country escape routes. Besides, with 4-wheel drive and an available V-6, it powers through dirt, sludge and sand as neatly as

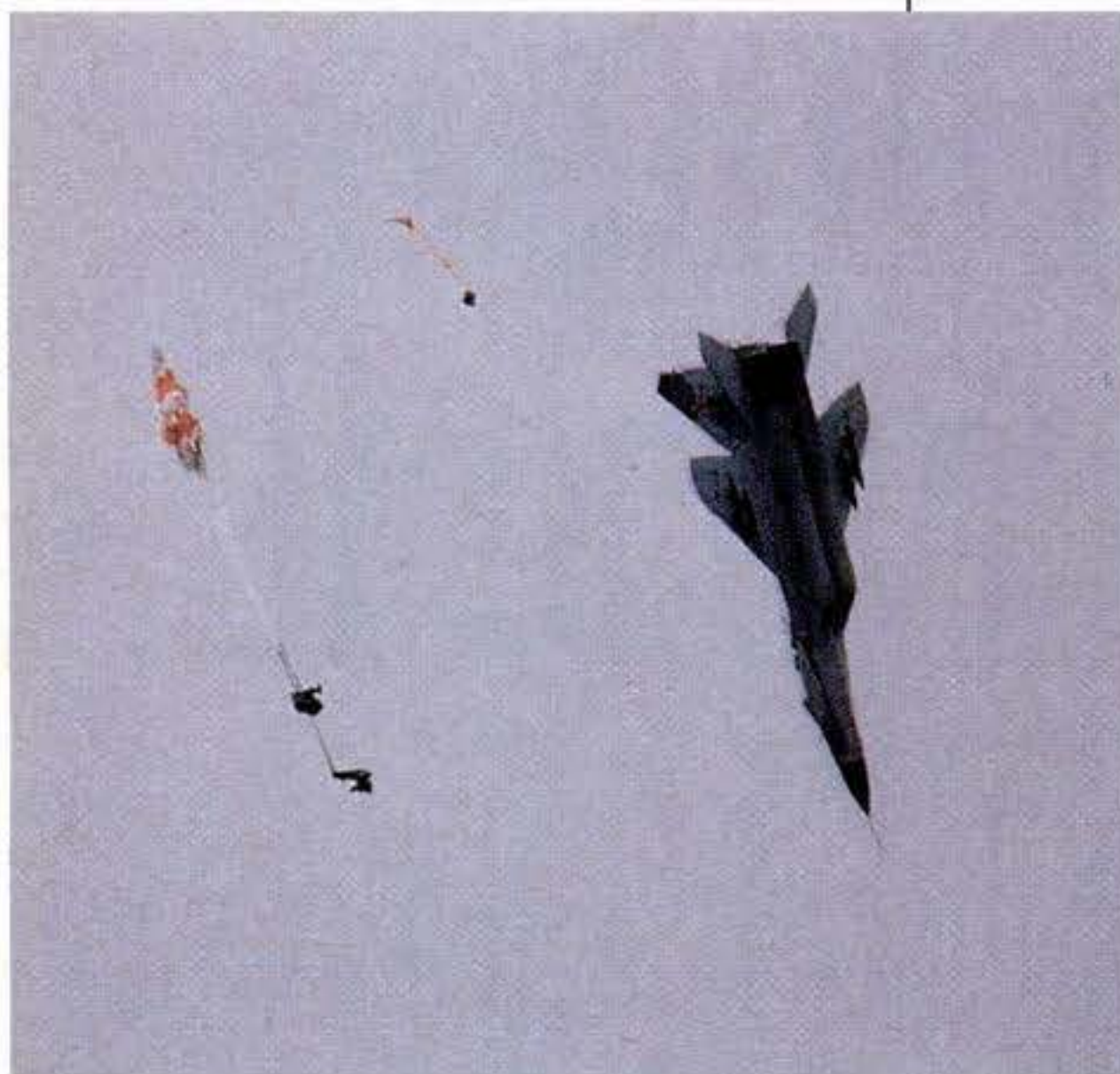
Are you still sitting here reading? The last thing we're going to say is buckle up for safety. That's it. Now, get going.



Power Ram 50

Science Newsfront

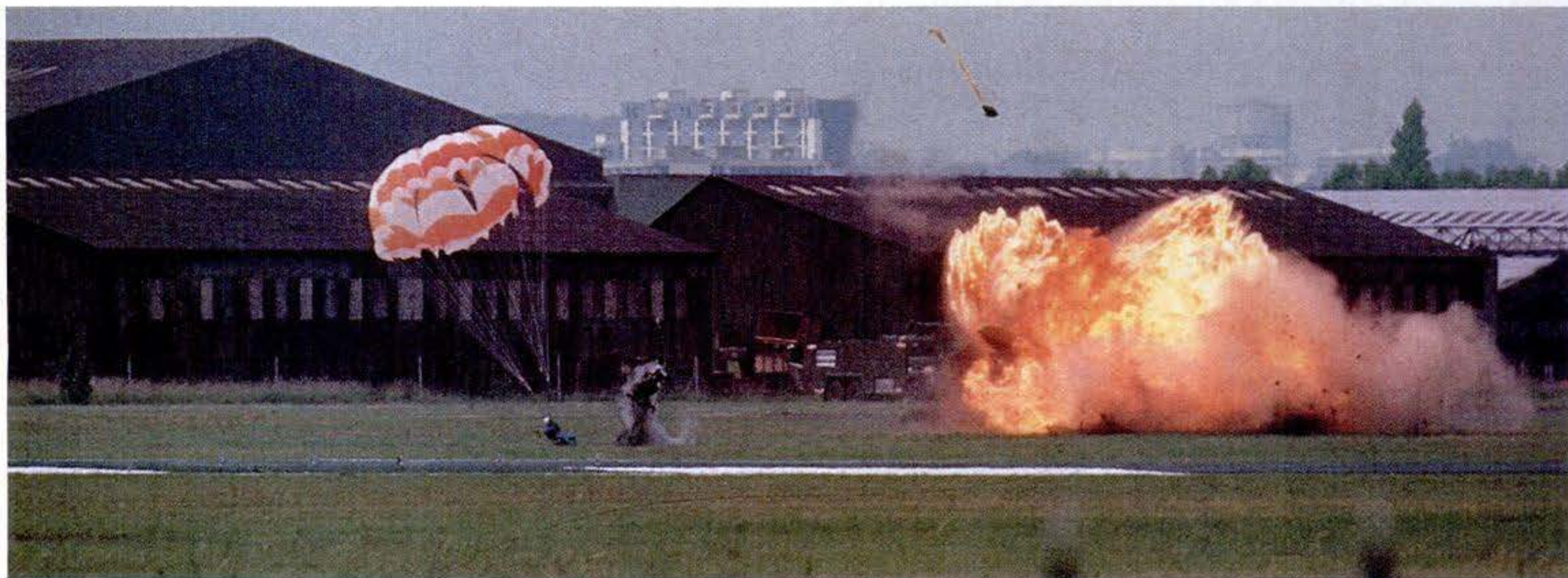
By ARTHUR FISHER



Soviet pilot Anatoly Kvotchur separates from his ejection seat as his MiG-29 dives steeply.



The ballistically deployed parachute, ejection seat, and trailing seat escape pack are all visible as the jet crashes into the ground.



With his parachute having just fully opened, Kvotchur lands with only minor injuries. Simultaneously, the MiG-29 explodes in flames, and the pilot's ejection seat bounces off the ground. Elapsed time from ejection was two seconds.

Air-show drama

Aviation history of a sort was made on June 8 at the Paris Air Show at Le Bourget airport as a horrified and transfixed crowd of spectators watched a Soviet Mikoyan MiG-29 plunge nose-first into the ground and explode, without killing its pilot, Anatoly Kvotchur. The miraculous escape was captured in this unique picture sequence by Swiss photographer C. Gluntz.

Kvotchur was attempting a maneuver called a slow-flight high-angle-of-attack pass at an altitude of 580 feet. The aircraft was accelerating when the right engine stalled, and the MiG went into a near-vertical dive. Kvot-

chur had just enough time to get clear; the plane sank its nose into the wet ground a mere two seconds after he ejected. Almost at the instant the pilot touched ground, the plane exploded in a fireball.

Somehow, Kvotchur suffered only minor injuries.

New moon for Neptune

The existence of a new moon orbiting the planet Neptune, tentatively discovered in June, was confirmed on July 5 by scientists on the triumphant Voyager Project at NASA's Jet Propulsion Laboratory (JPL). Temporarily designated 1989 N1, the new moon

joins the two previously known Neptunian satellites: Triton, discovered in 1846, and Nereid, discovered in 1949. Triton is between 1,500 and 2,500 miles in diameter, Nereid between 200 miles and 700 miles.

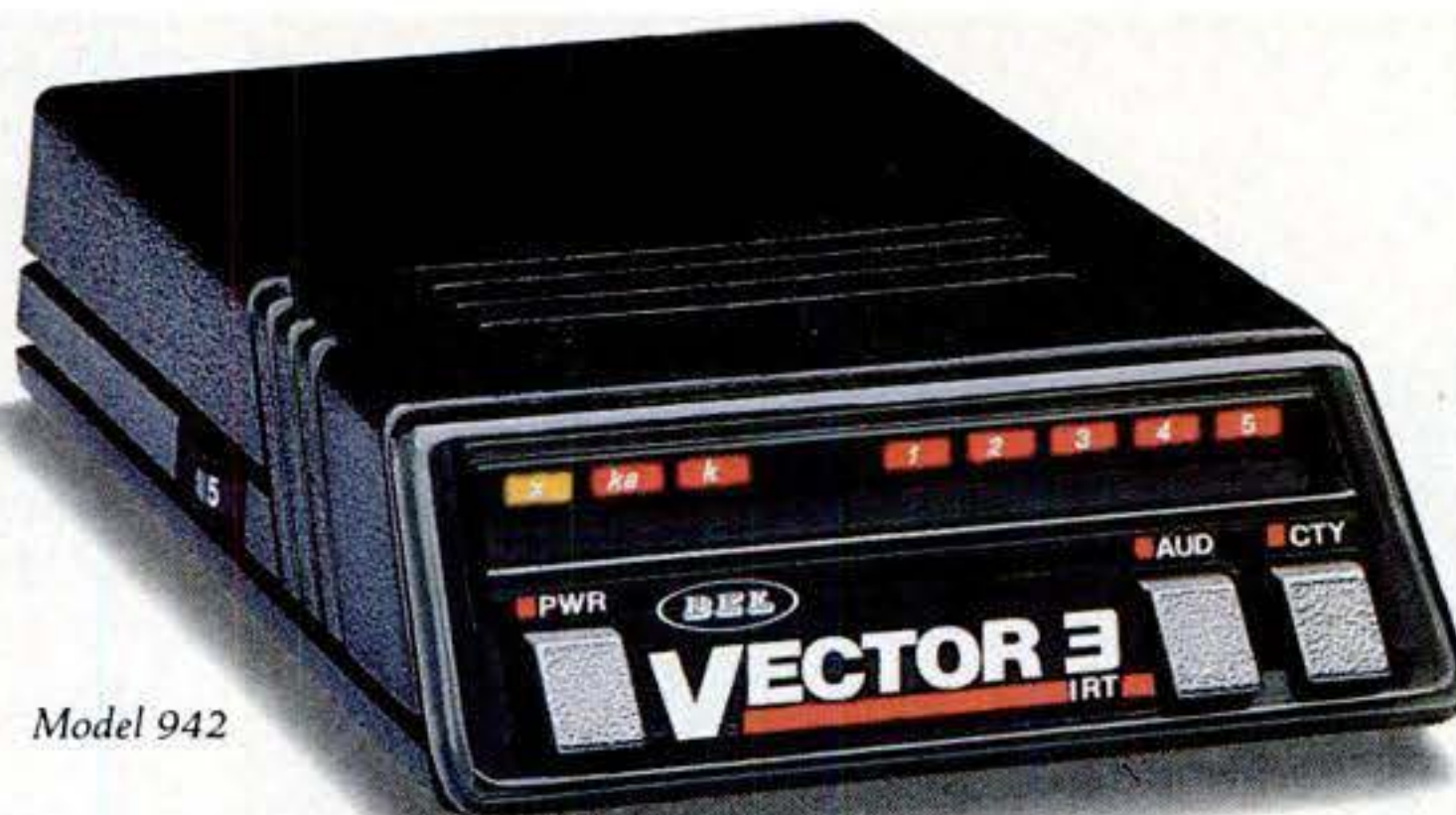
The new moon was originally observed by Dr. Stephen P. Synnott, a Voyager imaging team scientist at JPL, when he found a small bright smudge in images returned by the Voyager 2 spacecraft as it hurtled toward Neptune. According to Synnott, the July images confirm a nearly circular, equatorial orbit about 57,600 miles from the planet's cloud tops, or 73,000 miles from the center. The diameter, says Synnott, could range from

Continued

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The new VECTOR 3 impressively combines style, performance, and 3 band radar detection.



Model 942

While VECTOR 3's compact and well executed design can be confirmed by your eye, its performance advantage is confirmed by a number one rating in the most recent test conducted by Road & Track magazine:

"...Vector 3 maintains a BEL tradition of excellent sensitivity, posting the highest figures in this survey for both K and X band radar." *Road & Track*

Making this accomplishment even more impressive is the fact that VECTOR 3 posted the highest K and X band sensitivity levels ever recorded in any radar detector test!

VECTOR 3's top-rated performance is achieved by adapting a technology used in military satellite communications. It's called Image Rejection Technology®, or IRT®. And through its use, VECTOR 3 is able to identify weak police radar signals that other detectors simply miss – a definite advantage for detecting Instant On or Pulsed radar. And when Instant On or Pulsed radar is encountered, VECTOR 3 warns you with a separate audio alert.

Unequaled in performance, VECTOR 3 provides another important advantage – detection of Ka band police radar, now being used in both the U.S. and Canada.

In addition, VECTOR 3's high quality and ergonomic design make driving with the world's most advanced radar detector easy, convenient, and reliable. With VECTOR 3, leading edge radar detection never looked better!

Fully featured, VECTOR 3 is \$299.95 and comes with a one year warranty on parts and service. A remote version, VECTOR 3R, is also available for \$319.95.

To order, or for the name of a dealer near you, just call toll-free:

1-800-341-1401 USA
1-800-268-3994 Canada



New 3 band radar detectors for use in Europe are now available. Please inquire for more information. ®Registered trademark of BEL-TRONICS LIMITED.

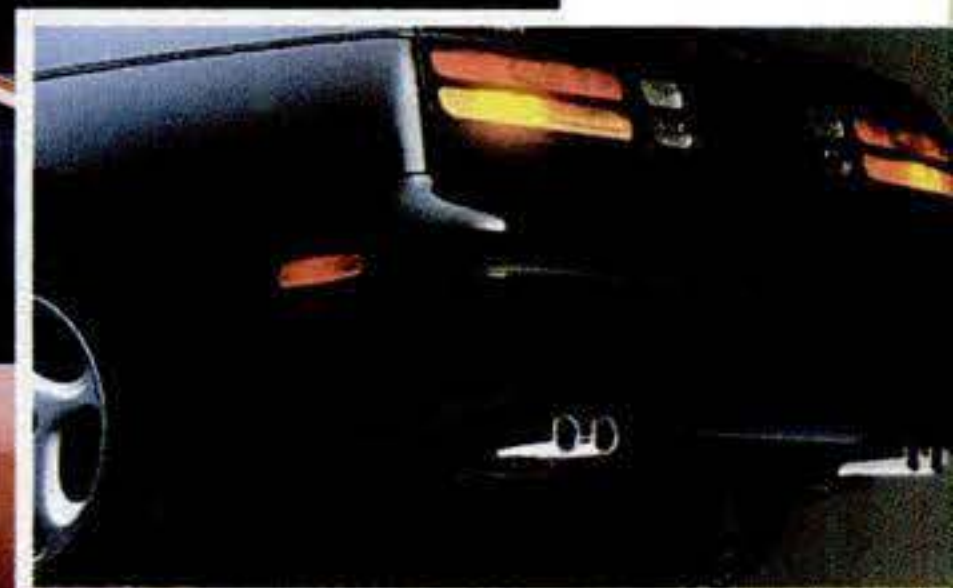
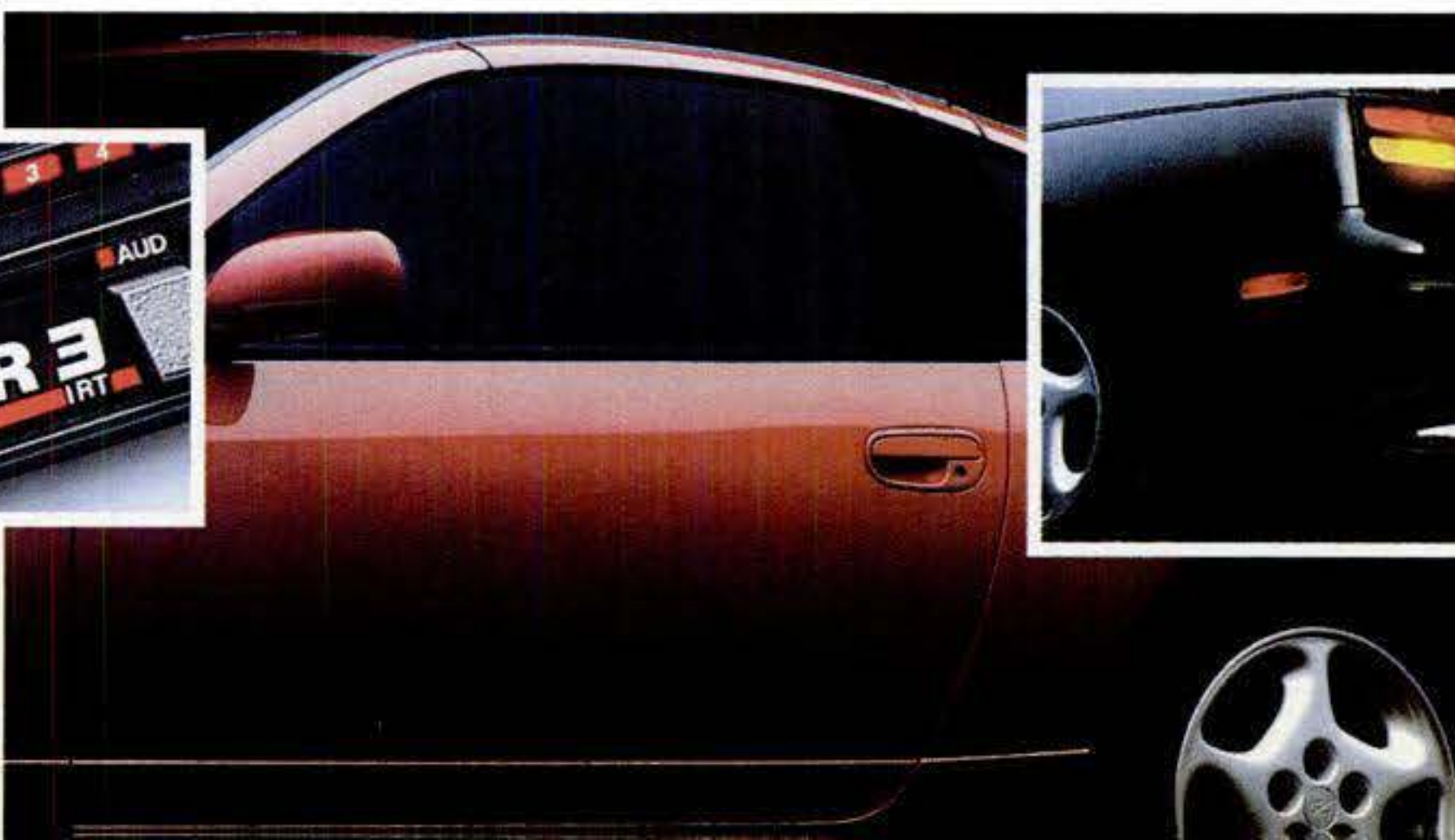
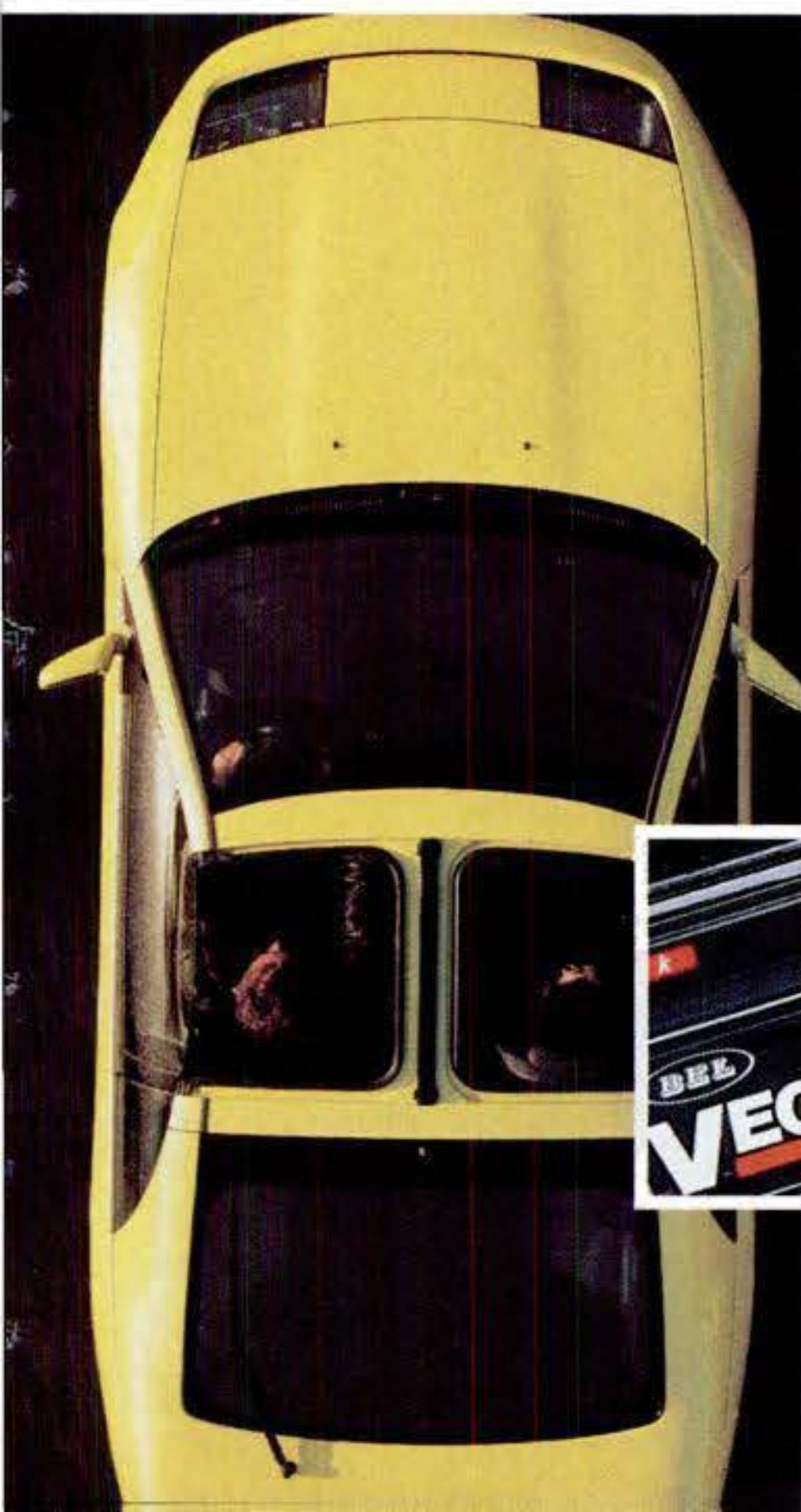
Laboratory Tests*		
Model	Sensitivity, dBm/cm ²	
	X-band	K-band
BEL Vector 3	117.2	115.6
Audiovox RX-4	104.1	93.9
Cincinnati Microwave Escort	112.9	106.8
Cincinnati Microwave Passport	114.1	107.8
Cobra Trapshooter RD-3170	113.4	110.8
Fultron 15-0900		
Snooper D-4000	109.4	108.8
Kraco KRD-16	102.7	104.7
Mascot PH222	101.5	94.6
Maxon RD-25	109.3	106.8
Radio Shack Micronta Road Patrol XK	107.6	106.0
Uniden RD9XL	113.1	108.8
Whistler Spectrum 2	115.6	110.4
Average unit	110.1	106.3

Source: Road & Track, Nov. 1988
BEL VECTOR 3 is the only unit in this test that also detects Ka band radar.

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PS942s

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Science Newsfront *Continued*

between 125 to 400 miles.

In early July, Voyager 2 was 43 million miles away from Neptune and headed for a close flyby of the planet on August 24. It will be the final planetary encounter for the Voyager 2 spacecraft, which was launched in 1977, and flew past giant Jupiter in 1979, Saturn in 1981, and Uranus in 1986. [Flash: On August 4, JPL announced the discovery of three more moons. More will probably be found.]

Buzzing the rabbiteye

Entomologists at the U.S. Department of Agriculture and Auburn State University have discovered a previously unknown bee they have named the "blueberry bee" because it is essential to the pollination of the rabbiteye blueberry. The rabbiteye, found mostly in the Southeast, is one of the three main types of blueberries grown commercially in the United States.

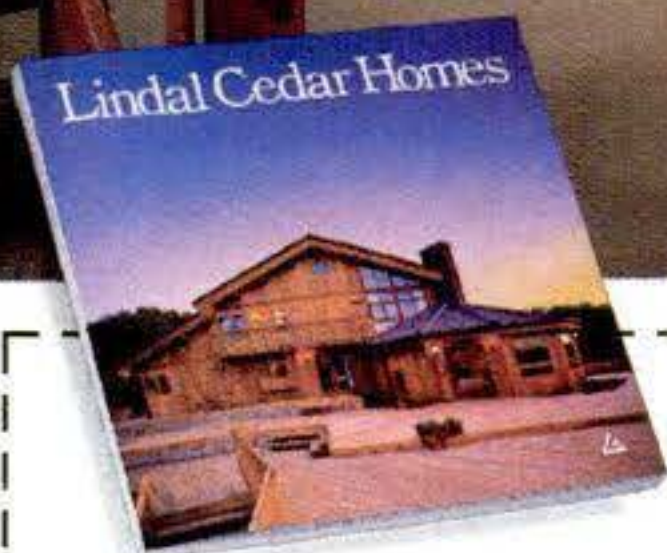
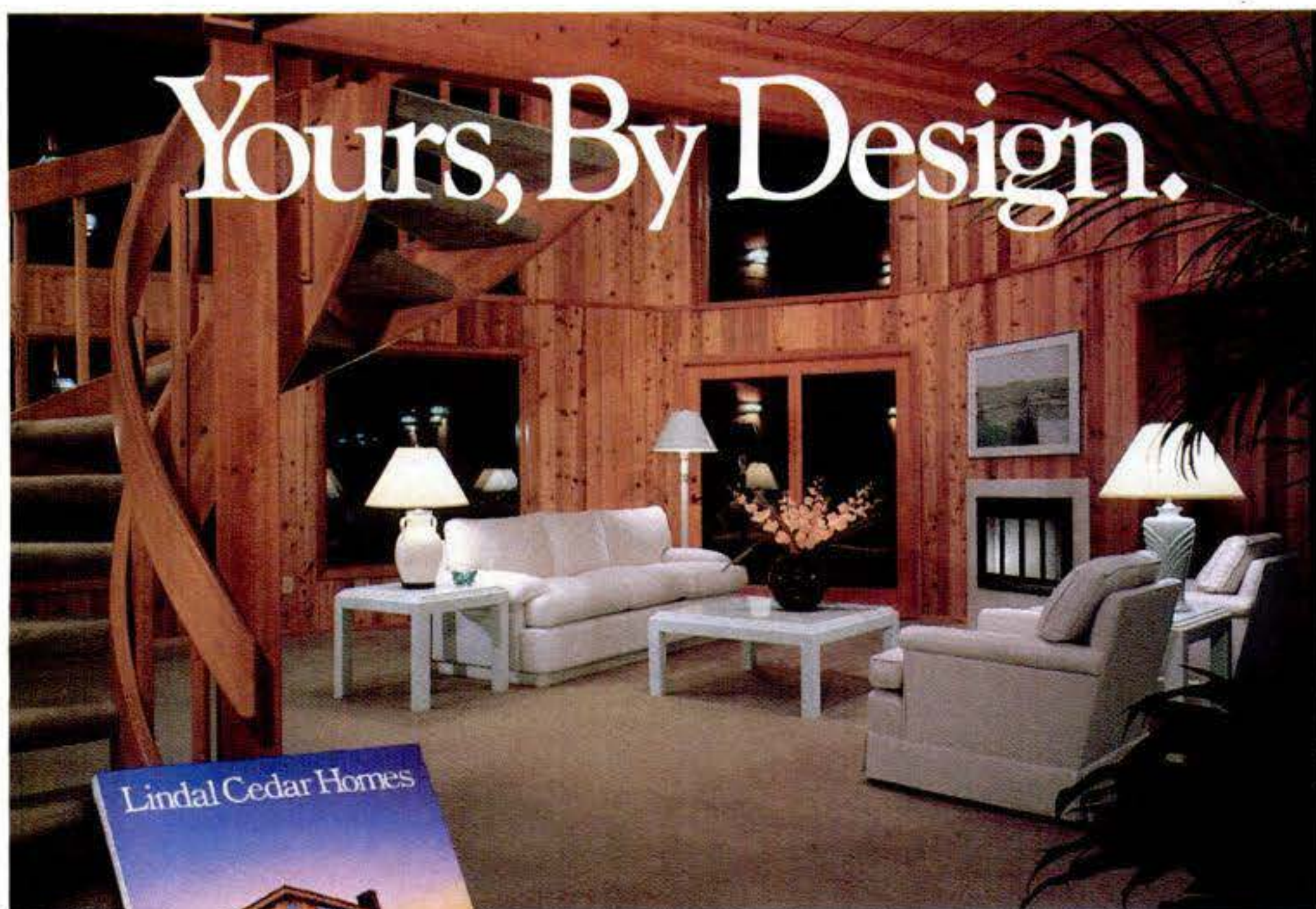
In the photo below, a female blueberry bee is seen foraging for pollen and nectar from a rabbiteye blueberry flower.

In the photo at right, entomologist Jerry Payne of the Agricultural Research Service's Southeastern Fruit and Tree Nut Research Laboratory in Byron, Ga., uses a bionic ear to listen for the telltale "sonication" of the bee. Seems that as it probes for nectar, the bee also loosens a cloud of pollen by buzzing. Pollen particles are scattered by the sound energy generated by rapidly vibrating indirect flight muscles.



Only the female blueberry bee buzzes these rabbiteye blueberry flowers.

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The motion resembles that of a tuning fork and can't be seen by the naked eye.

Whereas the honeybee can't pollinate the rabbiteye blueberry flowers, the longer-tongued blueberry bee can. The discovery promises future improvements in the size and yield of the berries. The 1988 rabbiteye blueberry crop was worth about \$3.5 million.

Metallic hydrogen

Geophysicist Ho-Kwang Mao and physical chemist Russell J. Hemley have reported to the National Science Foundation the successful transformation of gaseous hydrogen into a solid with the properties of a metal. Working at the Geophysical Laboratory at the Carnegie Institution of Washington, D.C., the two scientists squeezed hydrogen for the first time to pressures exceeding 2.5 megabars, or 2.5 million times atmospheric pressure at sea level. That approximates the crushing pressure at Earth's core.

Theoretical physicists predicted as long ago as 1935 that hydrogen could be made into an atomic metal under tremendous pressure, but that goal



Entomologist Jerry Payne eavesdrops electronically for the typical buzzing

sound of the blueberry bee. The vibrations stir up clouds of pollen.

has eluded experimenters until now. Hydrogen, the simplest and most abundant element in the universe, has an atom consisting of a single electron orbiting a nucleus that is a single pro-

ton. Pure hydrogen, a gas at normal temperatures and pressures, exists as a two-atom molecule, with the two electrons forming a stable shell.

But under extreme pressure, theory
Continued

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Although only 25 feet long, this recently flown prototype of the British CMC Leopard executive jet carries four passengers.

goes, the distance between hydrogen molecules could be reduced so much that it became roughly equal to the distance between atoms in a hydrogen molecule. And when that happened, molecular structure would crumble, and the result would be a solid consisting essentially of a lattice of hydrogen nuclei—protons—in a sea of

electrons. In other words, a metal.

Mao and Hemley did not reach the metallic form in a single stage, but went from a gas to a transparent, insulating solid, then to a semiconductor, and finally to the metallic solid.

"Instead of transforming abruptly to a fully metallic state at a critical pressure," Hemley said, "the hydrogen

changes gradually over a wide pressure range. It becomes brown and finally black. At the highest pressures, the electrons in the material appear to undergo electronic transitions expected for a metal."

The hydrogen was compressed in a diamond anvil, a device with the minute plane surfaces of two precision-cut



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gem-quality diamonds. Diamond is the only material strong enough to withstand the pressure without cracking. The sample of solid hydrogen compressed in the anvil was microscopic—one-trillionth of a cubic inch in volume.

Planetary scientists believe metallic hydrogen may form within the giant gas planets Jupiter and Saturn, where pressures may exceed 20 megabars. If so, the material could account for the planets' electromagnetic profiles. Geologists studying Earth's core, where pressures may be as high as 3.5 megabars, are intrigued by the possibility that metallic hydrogen—in addition to iron—is present there.

And some theoreticians speculate that metallic hydrogen might even be useful as a high-temperature superconductor, as a reactant in fusion experiments, and as a rocket fuel with an extraordinarily high thrust-to-weight ratio.

Tiny executive jet

No, not a plane for diminutive execs, but one that is amazingly short, considering it's a four-seater. The photo

(left) shows the British built and designed CMC Leopard, which first flew last December, and should go into production in the early 1990s.

Built of glass-reinforced plastics, the craft will have two turbofan engines developed by Noel Penny Turbines Ltd. It will have sophisticated electronics, auto pilot, and a de-icing system, and be fully pressurized. Its projected range would take it from London to Rome without refueling.

The project has been headed by Ian Chichester-Miles, former chief research engineer at British Aerospace.

Maglev planes?

Maglev stands for magnetic levitation, as all readers of POPULAR SCIENCE know by this time. The word following maglev is usually train. But a new study by engineers and economists at Argonne National Laboratory suggests that because of the constant air gap between a maglev vehicle and its guideway, such vehicles could be thought of as low-flying aircraft.

Indeed, the report states that superconducting maglev vehicles could be an ideal substitute for planes on short

intercity trips. Savings in fuel, together with a reduction in the costs of airport congestion, should be enough to pay for a maglev system linking airports in major cities from 100 to 600 miles apart.

Superconducting maglev systems have been shown to be effective based on low-temperature superconductors, the report notes; with the discovery of the new high-temperature superconducting materials, it may now be possible to build powerful magnets that are smaller and less expensive than before.

"Potential speeds of three hundred miles per hour," says Larry Johnson, director of Argonne's Center for Transportation Research, "make the airline market, rather than the train market, the primary application for maglev vehicles."

This country pioneered in maglev research in the 1960s and 1970s, but funding for development of the new technology evaporated in 1975. Research continued, however, in West Germany and in Japan, and both of those countries have now built full-scale working models of maglev trains [Dec. '73, Oct. '84].

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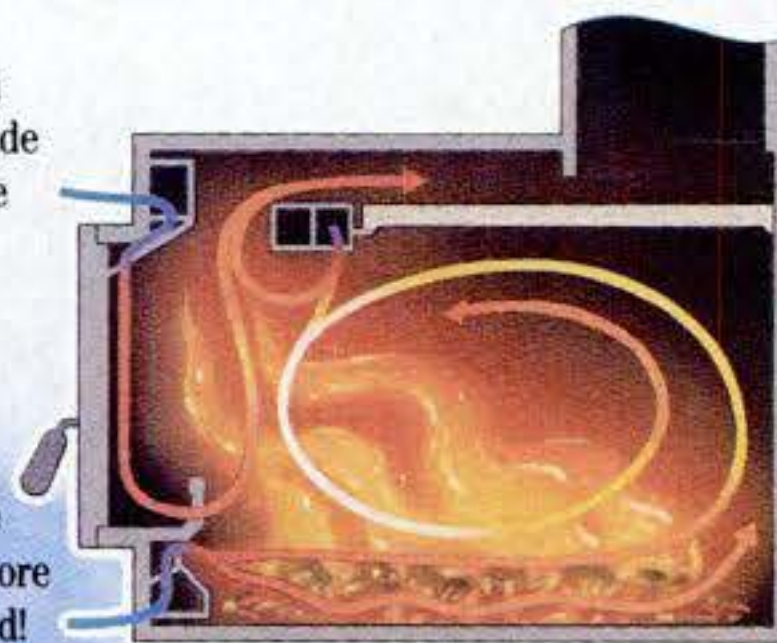
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Automotive Newsfront

By **DAN McCOSH** Detroit Editor with *Stuart F. Brown* in New York and *Brian Nadel* in Phoenix



The front-wheel-drive Nissan Stanza is powered by 2.4-liter single-overhead-cam engine that produces 138 hp. The

GXE model (shown above) is equipped with anti-lock brakes and cast-alloy nine-spoke wheels.

Stand-up Stanza

The 1990 Nissan Stanza is roughly the same size as the car it replaces—give or take an inch here and there. However, the four-door notchback has one of the largest cabins in the compact car class. Interior volume is 91 cubic feet, two more than the Toyota Camry and Honda Accord, but still less than the Plymouth Acclaim/Dodge Spirit. The Stanza has an abundant 14 cubic feet of trunk space.

Exterior styling is still a little boxy,

but the sharp corners have been rounded. And overall the car has a smooth, integrated look, despite a disappointing 0.34 coefficient-of-drag rating. The Stanza is driven by a slightly detuned version of Nissan's 240SX sport coupe's power plant that develops 138 horsepower. The front-wheel-drive car contains a viscous-coupling limited slip differential as standard equipment that allows it to be driven with confidence on wet pavement, or with wheels on different surfaces—a circumstance in which

most front-drivers slide sideways. With the standard five-speed manual transmission, the car can accelerate to 60 mph in 10 seconds, according to Nissan; an electronically controlled four-speed automatic is optional. The car's suspension is MacPherson strut—front and back—and provides a stable, firm ride that is well-behaved on a variety of road surfaces.

Computer-controlled clutch

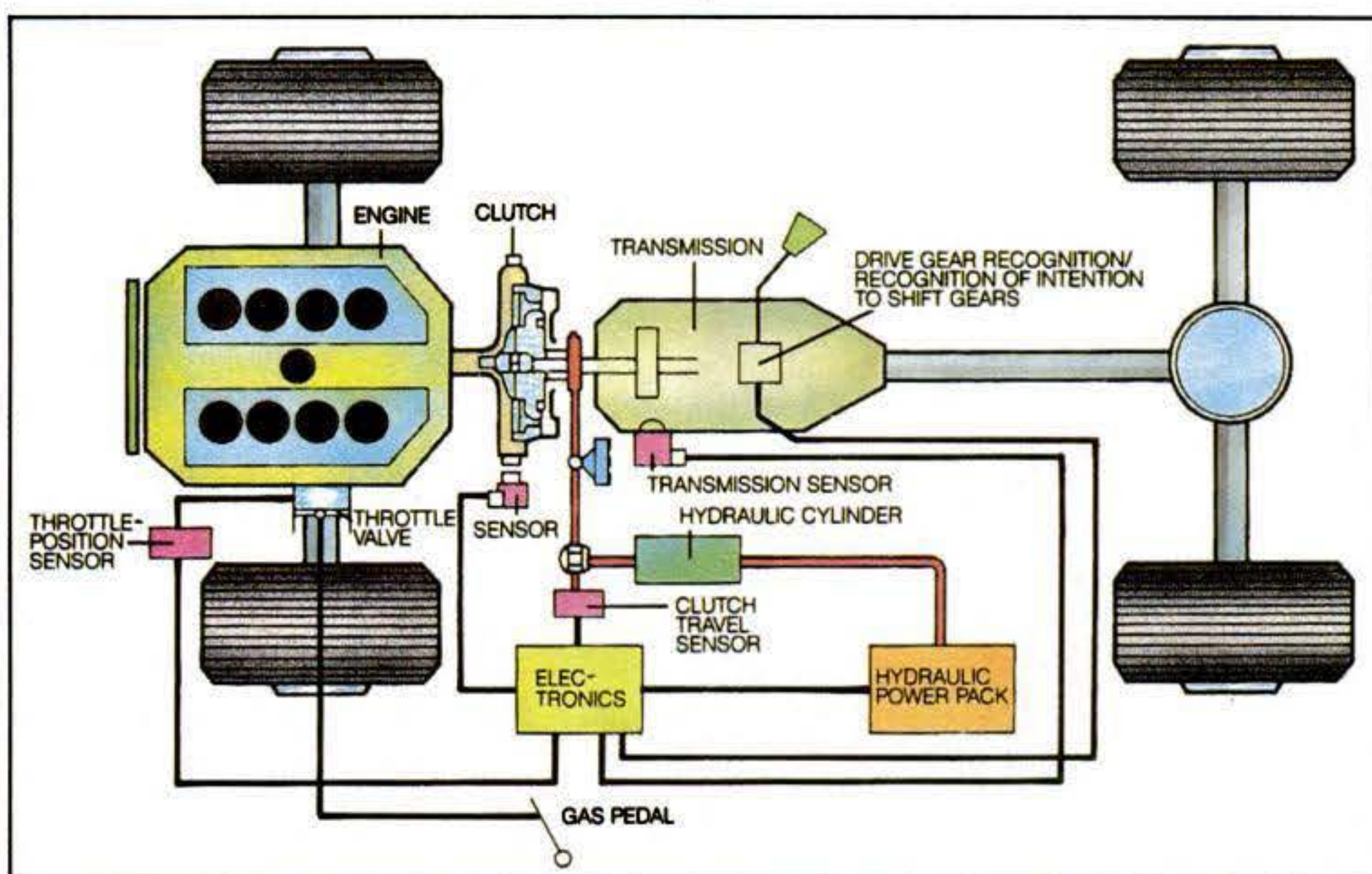
The Torque Control Isolation system designed by LuK, Inc., attempts to span the gap between automatic and manual transmissions, giving the best of both worlds: economy, efficiency, and control of a manual, with the ease of use of an automatic. There is no clutch pedal, and sophisticated electronic sensors and a computer monitor the operation of the hydraulically activated clutch. The shifter sensor (see drawing below) instructs the control computer of the driver's intent to shift gears, and the transmission sensor sends a confirmation when the gear is in place. The driver merely slides the shifter into gear, and the control computer does the rest, engaging the clutch when the accelerator pedal is pressed. The speed and amount of clutch engagement is determined by the throttle-position sensor. Whenever the shift lever is moved out of a gear, the computer instructs the hydraulic system to disengage the clutch. The clutch is engaged when the next gear is in position.

LuK engineers say the system is not only quieter than a conventional automatic transmission, but it also makes it impossible to stall or over-rev the engine, and the computer-controlled clutch slips slightly to absorb engine surges or spikes. LuK engineers have installed a prototype version of the Torque Control Isolation system on an Opel Omega for testing, but company officials say the transmission can be adapted for heavy-duty truck use.—*B. N.*

Asbestos-free autos

The EPA has set a timetable for the phase-out of cancer-causing asbestos products. By 1996 all clutch, friction, and other parts that currently contain asbestos will have to be replaced by substitute materials.

Continued



Gear shifts in LuK Torque Control Isolation transmission are computer controlled for optimum efficiency. The driver moves the shift lever as in a manual transmission. Sensors monitor

the shifter and transmission, and when the gas pedal is pressed, the hydraulic clutch is engaged. When the shifter is moved out of gear, the clutch is automatically disengaged.

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See NASA Tech Briefs for technical details, 1986, 1987 and 1988.

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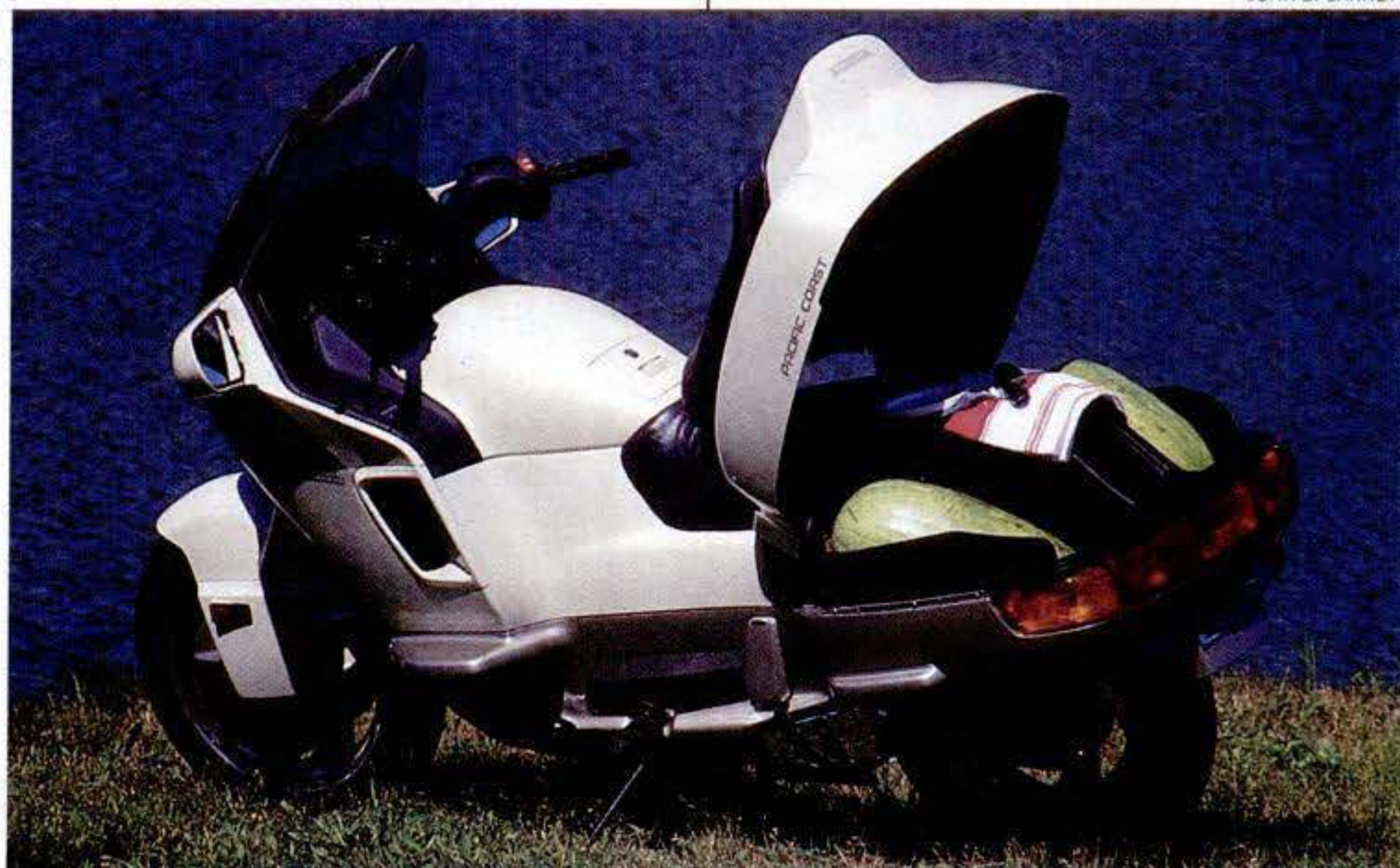
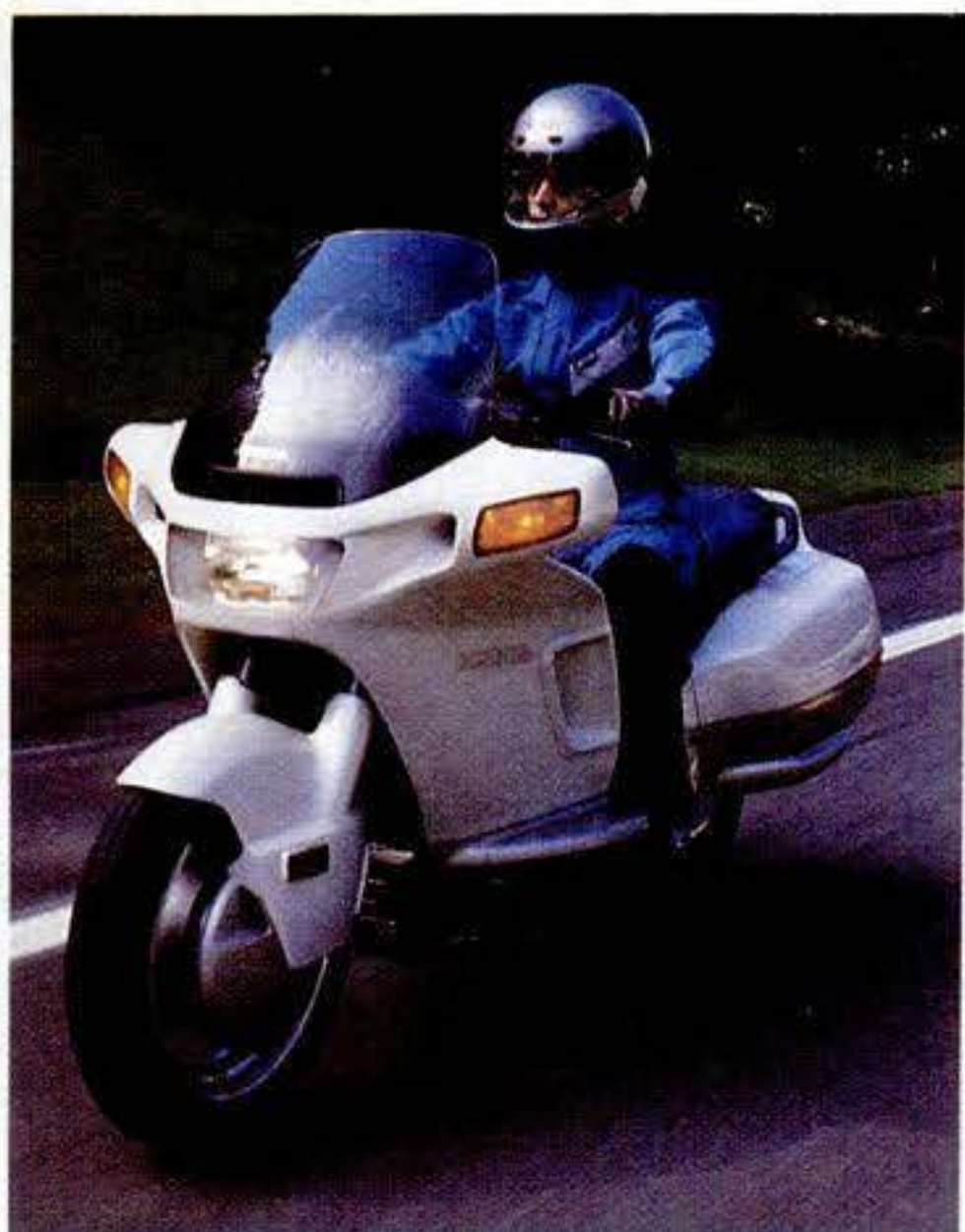
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Gumdrop bodywork encapsulating the Pacific Coast (above) lets it slip unruffled through the airstream. The soft-edged look is calculated to counter "scary-motorcycle" anxiety in the uninitiated. Try this with your plain-Jane bike (right): A pair of strapping melons arrive at the picnic site unbruised. A gas-charged cylinder opens the trunk lid—just like a car.

Bike with a trunk

For several years, most motorcycle makers have faced increasingly grim sales. Three factors contribute to the industry's doldrums: bargain-priced

models left over from market-share wars of the recent past; an abundant supply of affordable used bikes; and the often-fatal sticker shock many younger would-be buyers experience on the showroom floor.

Honda hopes it has figured a way out of the decline: Aim for a somewhat older crowd, the style-conscious "professional earning a substantial income," who might not have previously considered the sport of motorcycling.

Flushing With Water Just Doesn't Wash.

Sounds plausible, but what if these yuppie bikers are put off by the starkly mechanical—even dangerous—look of many motorcycles? No problem. Bring in the automotive division's stylists to sculpt a flowing, all-enshrouding body.

Make the instruments and controls—though no less complex than the average cycle's—appear simple and inviting. Then incorporate a handy trunk into the machine's scooterlike rear end. Hey...wait a minute! A bike with a trunk? Come on now... But, yes, that's the Pacific Coast, Honda's user-friendly and altogether carlike departure from the traditional motorcycle.

Collecting a PC for a road test (and reflecting on those initials), I thought it looked ponderous, something like the leviathan touring bikes that have always reminded me of 1960s Buicks. Climbing aboard, I felt vaguely embarrassed about the trunk, and deprived of visual contact with the metal innards of the machine. Sure enough, out on the road, it wasn't too long before a wag on a BMW cycle pulled up and inquired: "Is there a bike in there?" Ho ho ho.

The rest of the cyclists who looked the machine over took a more respectful tone, with many voicing admiration for the futuristic packaging mixed with curiosity about what it concealed. None of this prepared me for the exuberant reactions of pedestrians who clearly didn't know the first thing about motorcycles. It's safe to say the Pacific Coast made a winning fashion statement on the streets of Manhattan, where one observer shouted, "Yo, what is that? It looks beautiful!"

Enough about looks. The bike turns out to be a charm to ride. It's truly at home on interstate highways, where it will hum along plushly all day. But the big surprise is the PC's performance on twisty roads, where the bike leans into turns with unexpected ease and stability. A low center of gravity contributes to this good behavior, which is equally evident during parking-lot maneuvers. The PC's 800-cc V-twin engine is set low in the frame, where it belies the machine's 635-pound fueled weight. The big rubber-mounted twin is tuned for low- and mid-range torque, which it delivers amply and smoothly. Capable brakes and suspension complete the package.

Minimal maintenance is a key element of Honda's Pacific Coast strategy. After all, the type of new buyers they want probably don't work on their cars. With a hydraulic clutch, hydraulic valve adjusters, electronic ignition, a maintenance-free battery, and shaft final drive, there's not much to do beyond oil and spark-plug changes.

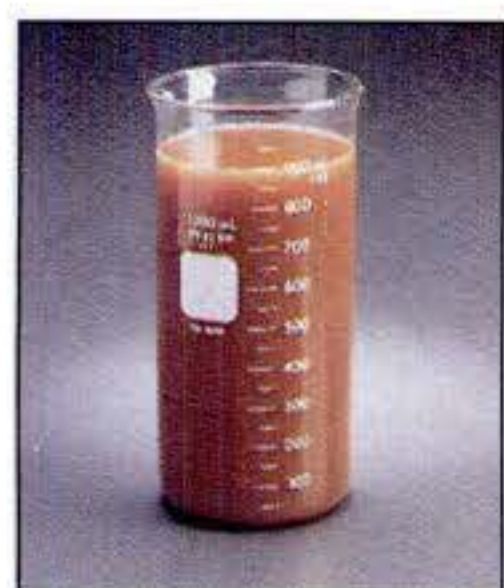
The verdict on the Pacific Coast? At \$7,700 it's an expensive but genuinely satisfying mount for the sporty-minded touring rider, who'll be able to stow a good amount of gear—safe and dry in that whimsical trunk. The acres of wind-tunnel-refined body panels—well, you either like them or you don't. While they efficiently manage the flow of air around the bike, they also shout PLASTIC! On balance, the PC is a demonstration of imagination during hard times on Honda's part. But will it fly? Only if those high-earning, design-maven types really do want another new appliance that's also a motorcycle.—S. F. B.

Ozone-friendly hoses

Taking a slightly different tack on the ozone-depletion problem, Goodyear en-

Continued

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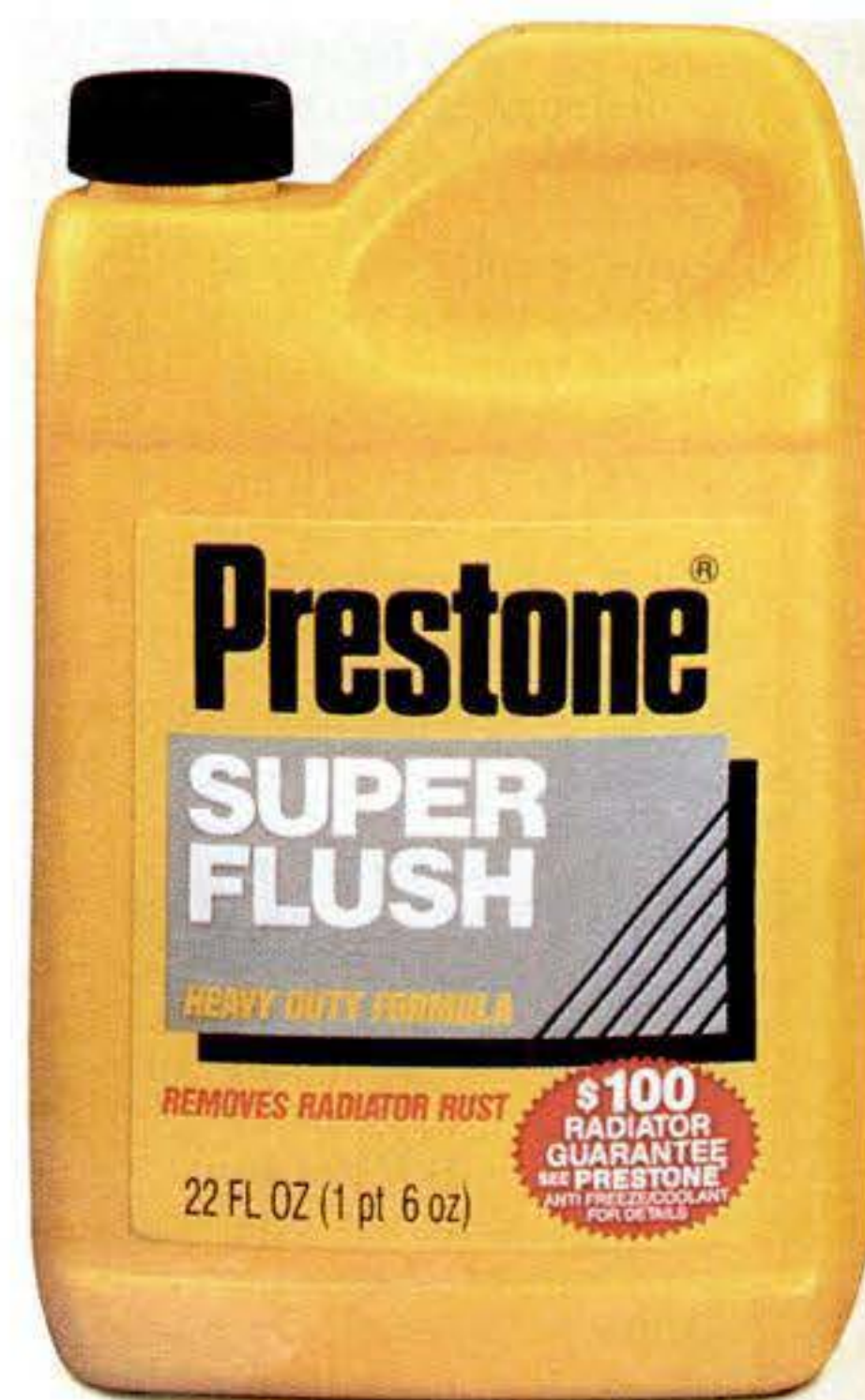
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gineers are trying to limit the amount of chlorofluorocarbons that escape from a car's air conditioner. According to the company, they have developed a new air conditioner hose with a barrier layer of nylon that lowers the leakage of ozone-depleting R-12 chlorofluorocarbon by 90 percent.

Quiet tires

Resolving the conflicts that exist between performance and comfort in a

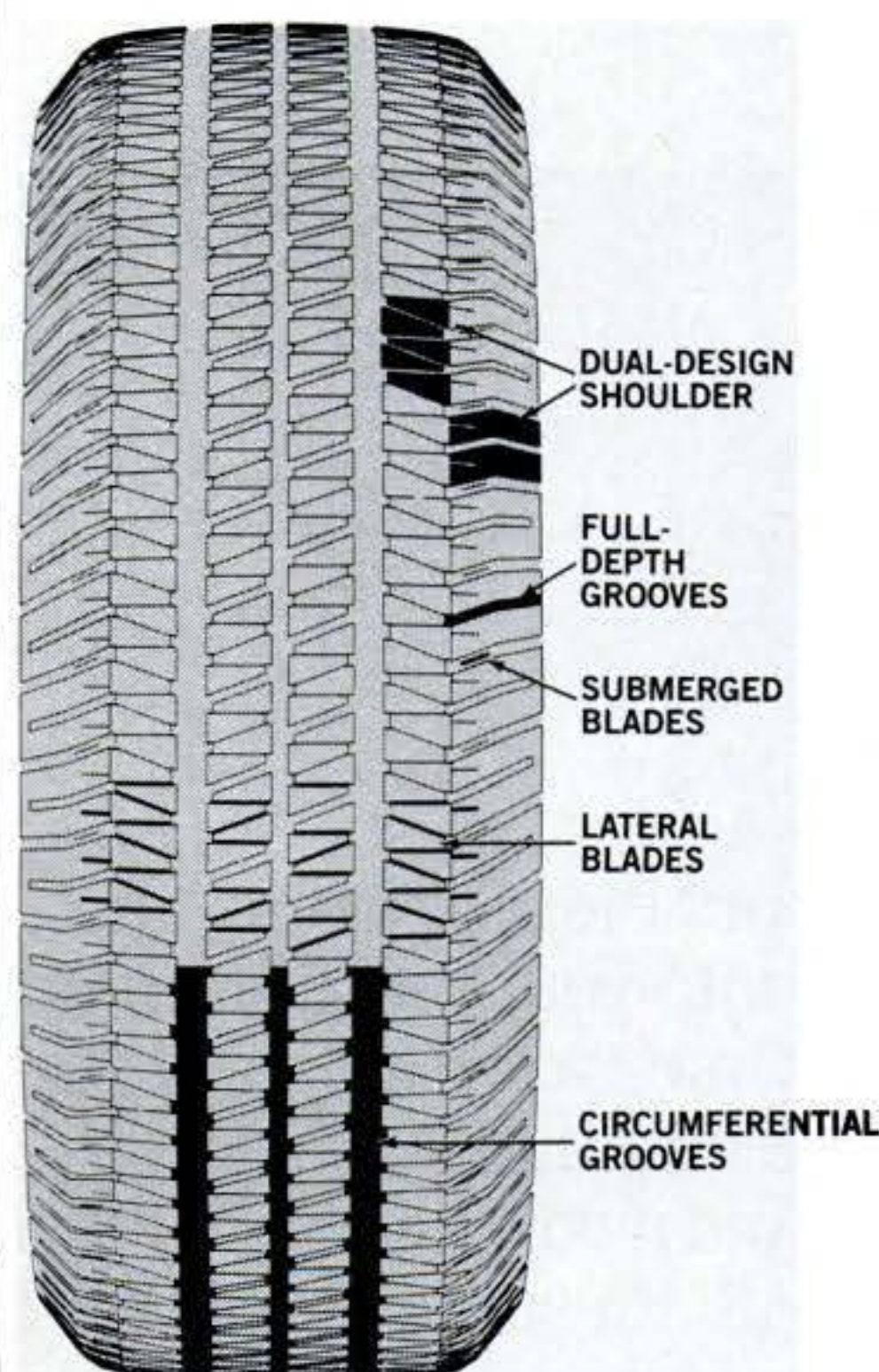
tire design has never been easy. Too soft and control is lost; too hard and ride quality suffers. Now Goodyear has come up with a performance tire that is quiet over the road and gives a smooth ride, yet tenaciously grips the road.

The Eagle GA radial is based on the successful Eagle GT line of tires, but with the advantage of using computer-aided design to quell many of the unsettling aspects of performance tires. Beale Robinson, Goodyear chief

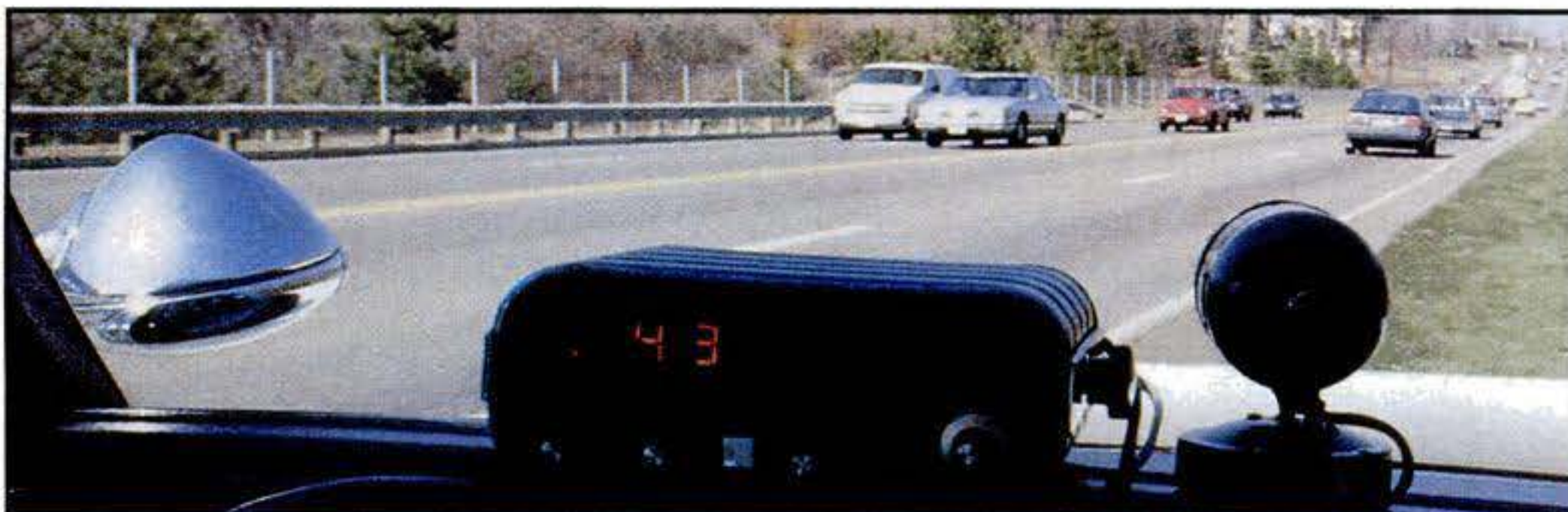
engineer of passenger tire programs, explains that the proper placement of small, compliant tread elements that soak up road noise and vibration (see drawing) is the key. He says that Goodyear tests show the Eagle GA gave off 84 decibels of road noise, compared with 88 decibels for standard radial tires and 91 for high-performance tires, when driven at 62 mph. To test traction, Goodyear engineers used a skid trailer where the tires were analyzed for slip against the pavement. According to Robinson, the GA radial scored about 10 percent better than standard tires and is only marginally inferior to high-performance tires in dry-pavement tests.

I had a chance to try these tires out for myself on a variety of cars, from the Lincoln Continental to the Nissan Maxima, while driving from Phoenix to the Grand Canyon and back. The tires gave a consistently comfortable and quiet ride, even when pushed to the limit. And that's exactly what happened when I drove into a reverse camber turn, going just a little too fast. The grip held fast and remained mannerly and controllable at all times.

Robinson says these tires were "designed to complement the chassis of the world's finest touring sedans." The Eagle GA will be available at first only as original equipment on luxury sports sedans, such as Toyota's Lexus LS 400.—B. N.



Goodyear Eagle GA tire has circumferential grooves and lateral blades to drain water and provide lateral grip; 200 grooves enhance traction.



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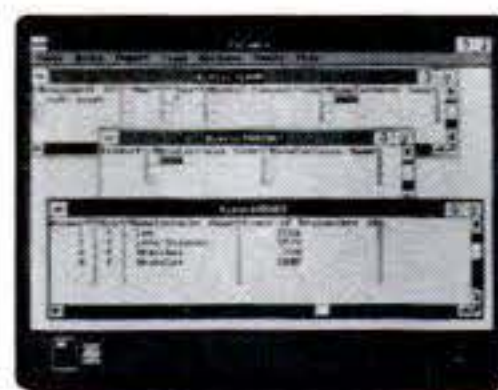
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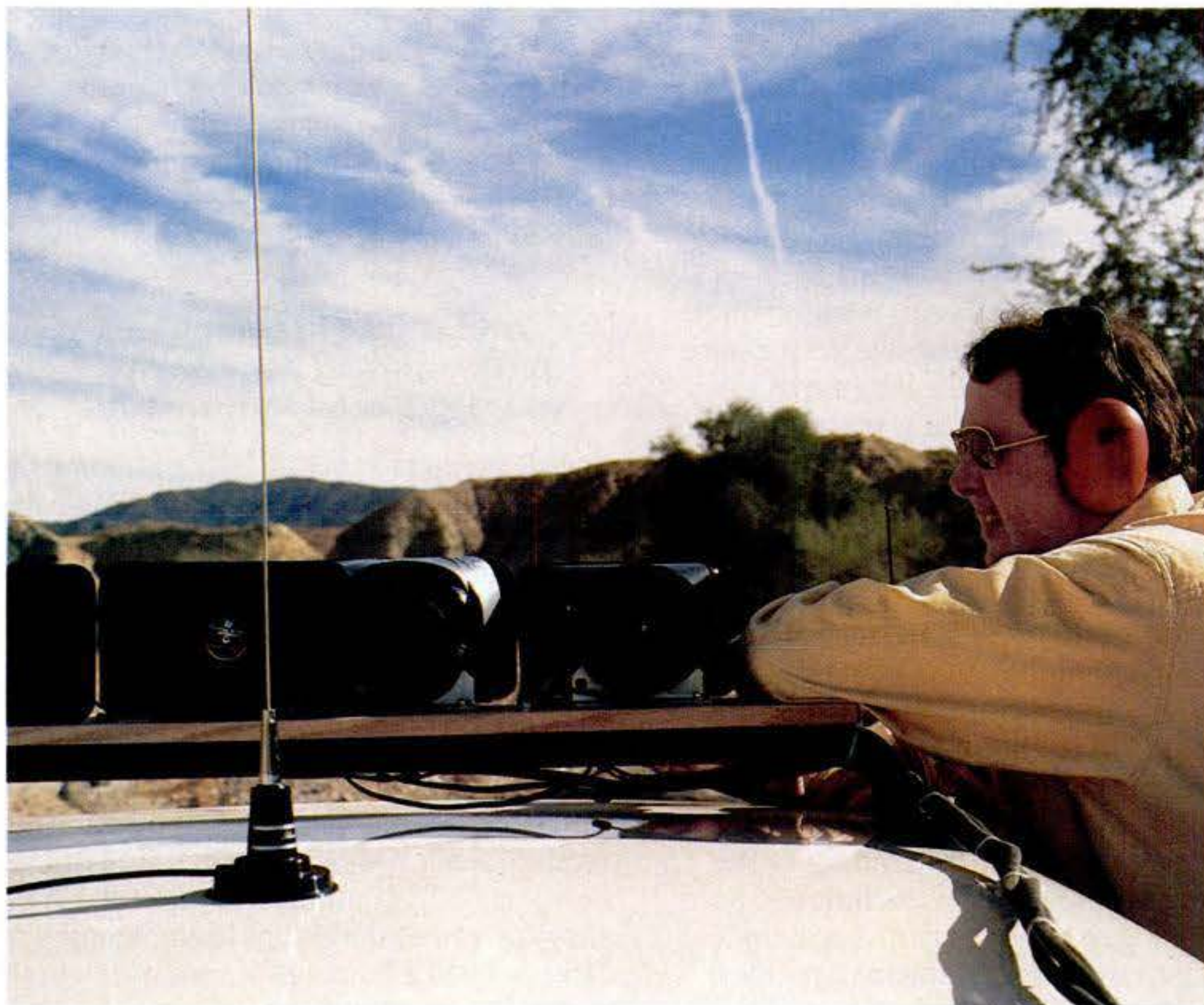
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Electronics Newsfront

By **WILLIAM J. HAWKINS** with Mariette DiChristina, Len Feldman, Richard L. Stepler, Dawn Stover, and Jack Wynn



Max Neuhaus tests the speaker system of a siren he invented. The sound is

pulsed to help other drivers locate and avoid emergency vehicles, he says.

Sounding off...safely

Pedestrians pausing on a safety island in the middle of a busy Manhattan street can hear a rich hum resonating against the backdrop of honking horns and squealing brakes. The hum is the brainchild of Max Neuhaus, who specializes in creating "sound environments." A former percussionist with a master's degree from the Manhattan School of Music, Neuhaus abandoned his musical instruments in the late 1960s and went to study at Bell Labs. There he learned how to construct the electronic equipment he now uses to generate and manipulate sounds.

Neuhaus, who once composed a piece for 10,000 people to whistle over the telephone, has no shortage of unusual ideas. But his latest project is a serious one: A siren that helps policemen, firemen, and ambulance drivers safely navigate city streets. The siren emits bell-like tones that reveal what direction an emergency vehicle is coming from and how fast.

According to Neuhaus, president of Siren Sounds, which is located in Englewood Cliffs, N.J., conventional si-

rens have several dangerous flaws:

- They're difficult to hear through a closed window, particularly with a car stereo blaring.

- They give no hint of direction. Drivers who do hear the noise often can't tell where it's coming from, so they respond by stopping in the middle of the street or even turning into the path of the emergency vehicle.

- They drown out other sounds. Emer-



Checks and credit cards are read and electronically verified within seconds by a Celerex computer system.

gency vehicle drivers can't hear each other, and they occasionally collide at intersections.

Furthermore, says Neuhaus: "Conventional sirens send sounds in all directions, contributing to noise pollution."

To prevent those problems, Neuhaus's siren speaker system emits bursts of sound in two narrow beams—ahead and behind the vehicle—which can be followed by ear even when out of sight, claims Neuhaus. The bursts are separated by short silences, which also help drivers find the sounds. "The mechanism for locating a sound depends on a rather delicate—though automatic—comparison of the differences in the onset of the sound between the two ears," Neuhaus explains. "This mechanism works very well for the sound of a twig snapping, but is quite useless with continuous sounds." The silent periods also enable emergency vehicle drivers to hear each other.

Neuhaus' siren can produce four different types of tones, which, he says, can be used to indicate different degrees of urgency. The emergency vehicle's speed also affects the signal: The faster it goes, the more rapid the sound bursts.

Neuhaus blocked off a few streets in Oakland, Calif., earlier this year to test the Siren Sounds system. Additional testing took place in the desert, using cliff walls as a substitute for skyscrapers. The system performed as expected.

Neuhaus, who has been working on one project for 15 years (he'd like to fill the visual void in a Paris subway tunnel with a sound network), is optimistic. "We may be entering a kind of sound renaissance," he says. "In the past five years, techniques for making and shaping sound have taken quantum steps, and for the first time in history, one can say that a real palette for sound exists."—D. S.

A quick buck

Imagine writing a personal check at a fast-food restaurant—and then expecting fast service. That might be possible soon. Celerex Corp. of Seattle has developed an electronic point-of-sale system that validates check purchases without a sales clerk making time-consuming authorization calls.

The system is designed for traditional "cash only" businesses that handle large numbers of customers quickly. A Celerex CX9000 microcomputer installed at each site is loaded every day via modem with fresh "stop file" numbers (lost, stolen, or bad accounts) from Telecheck, Visa, MasterCard, and Discover. The computer compares the numbers with those it gets from the point-of-sale terminals that instantly "read" customers' checking accounts and credit cards. After a sales clerk keys in a transaction account, the purchase is authorized, processed, a receipt is issued, and the information is stored for transmittal later via modem to a bank. Elapsed time: seconds.

Seattle-based Skippers seafood restaurant chain with 220 sites in 15 western states tested the Celerex system last year in Denver. Sales at 15 participating restaurants jumped by 16 to 18 percent. Now Skippers is expanding Celerex installations to 34 more restaurants in Oregon. Burger King and Kentucky Fried Chicken are also trying the system. Says Celerex President José Porto: "The system works equally well for theaters, convenience stores, airport parking lots, and amusement parks."—J. W.

Electronic fingerprinting

The FBI is considering a new mobile fingerprint and mug-shot scanner system to link police patrol cars to the agency's National Crime Information Center computer in Washington, D.C. It will enable two-way transmission of fingerprints and mug shots to identify wanted criminals almost instantly—while innocent suspects would go free without delay.

For example, with the system, a suspect picked up in Maine for a minor infraction could be tied to a series of brutal crimes in California. "It's not a 'Star Trek' fantasy," adds FBI director William S. Sessions. "I've seen it work."

"It's a two-way process," says David Hall, director of national identification sales for Fingermatrix, Inc., of North White Plains, N.Y., which developed the system. "Going the other way, you could send a photograph of a missing child over the network. Having the picture is more helpful than just a physical description. And the information could be printed out in the patrol car."

When the right index finger is placed on the small scanner, a video image is created (see photo). The image is sent to a transceiver in the trunk of the car, which transmits the information by audio signal. An identical

transceiver reproduces the video image, which is enhanced and sent by modem as digital signals to the NCIC. The process is reversed for the trip back.

Originally developed for access-control equipment, the Fingermatrix system matches prints on the basis of minutiae, the points where fingerprint ridges fork or end, a method used by law-enforcement officials for more than a century. Eventually the system would be able to compare an electronically scanned print with a data base of the 300,000 or so prints of known criminals now in NCIC files.

Prototype equipment was recently tested successfully by the Aurora, Colo., and Santa Barbara, Calif., police departments. But it may be awhile before the system is part of the NCIC: Funds have yet to be appropriated for it by Congress.—M. D.

DAT: Here it comes . . . again

Digital audio tape recorders—DAT machines—make perfect copies of original material. That's great for us, bad for the recording industry. Record companies claim that identical pirate copies of CDs and DAT tapes could

cost them millions of dollars a year in lost revenues. So for three years they have stalled the formal introduction of DAT machines in the United States. Now the record companies and

Continued



Police cars could be linked with the FBI to identify criminals within minutes with electronic fingerprint scanning and mug-shot transmission.



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DAT manufacturers seem to have agreed on a solution.

It's a circuit called SCMS—Serial Copy Management System. DAT machines equipped with SCMS will let you record an original CD or DAT tape as many times as you want. That lets you create custom libraries for use at home or in the car. But the copies cannot be used to create other copies. That stifles the pyramid effect caused by copies creating other copies, which are then used to create even more copies.

The system is based on a previous idea called Solo, developed by N.V. Philips, and uses two bits of data in the digitally recorded information to determine if the material can be copied. But unlike Solo, which ignores analog recording sources (records, standard audio tape, and microphones), SCMS applies its copy protection to analog inputs too: The digital copy of your favorite record can only be copied once.

In a meeting held in Athens earlier this year, the Recording Industry Association of America, the International Federation of Phonogram and Videogram Producers, and DAT hard-

ware makers, have agreed to seek legislation to implement scans on all future machines. While the circuit will add little to the price of a DAT, it will take time to implement. Look for machines sometime early next year.—*L. F.*

Phone home

"Hello. This is telephone number 914-329-8800. Alert conditions OK. The temperature is 45 degrees. The electricity is on. Sound level OK. Have a good day."

That was my country house speaking. I'd just called—from my New York office 115 miles away—to check the interior temperature on a winter day when the outside temperature was five below. Not that I'd have to do the calling to make sure the house was warm enough to prevent pipes from freezing. I can program up to four phone numbers for Heath Zenith's new House Sitter Security Monitor/Dialer to call automatically to report a malfunction or emergency.

Installation is easy: Just plug House Sitter into a phone jack (I replaced a single telephone jack with an RJ11C

duplex jack) and into a wall outlet. Batteries provide backup in case of a power failure. The unit is compatible with phone answering machines, but cannot be used on party lines or with coin operated phones.



House Sitter can talk you through programming with its synthesized voice. With the keyboard, you can ask the unit what the inside temperature is.

House Sitter monitors these conditions: inside temperature, comparing it with high and low limits you select; electric power outages; loud noises such as breaking glass and smoke, or burglar alarms; plus one additional

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Winston

FILTERS

WINNING

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sensor such as a normally open or closed switch on a window or door.

When you phone in to check conditions (House Sitter can be programmed to answer after 1 to 99 rings), you can also listen in through the unit's microphone for up to 99 seconds. Heath sells the House Sitter for \$130.—*R. L. S.*

Quick looks

- Eveready's Generator nickel-cadmium batteries (AA, C, and D sizes) can be recharged to 90-percent capacity in one hour. Until now, the process could take up to 14. The special charger is \$50; battery packs start at \$8.

- Making your office computers work together usually requires a LAN—local area network—made by stringing wire from one system to another. Now there are two easier ways: Photonics Corp. has infrared transceiver boxes that are attached to the backs of all the Apple computers in your office. Result: They all communicate with each other via infrared light. (Up to four computers can be connected to one \$995 photo-link box.) Need to incorporate computers that are out of

light sight—such as on another floor? Then there's the LAWN—local area wireless network—from O'Neill Communications, Inc. Each computer (and printer) gets a \$500 add-on box that communicates with other boxes via spread-spectrum radio transmission. What's spread spectrum? The transmission is broken up and spread over a band of frequencies, thereby eliminating the possibility of data loss or errors due to interference on any one frequency.

- Motorola has developed a single-chip AM-stereo receiver. For instant music, just add a battery and earphone.

- Ovonic Imaging Systems has introduced an eight-inch-square full-color active LCD cockpit display. Designed for cockpits, the 1.7-million pixel device is the largest active display made in the United States.

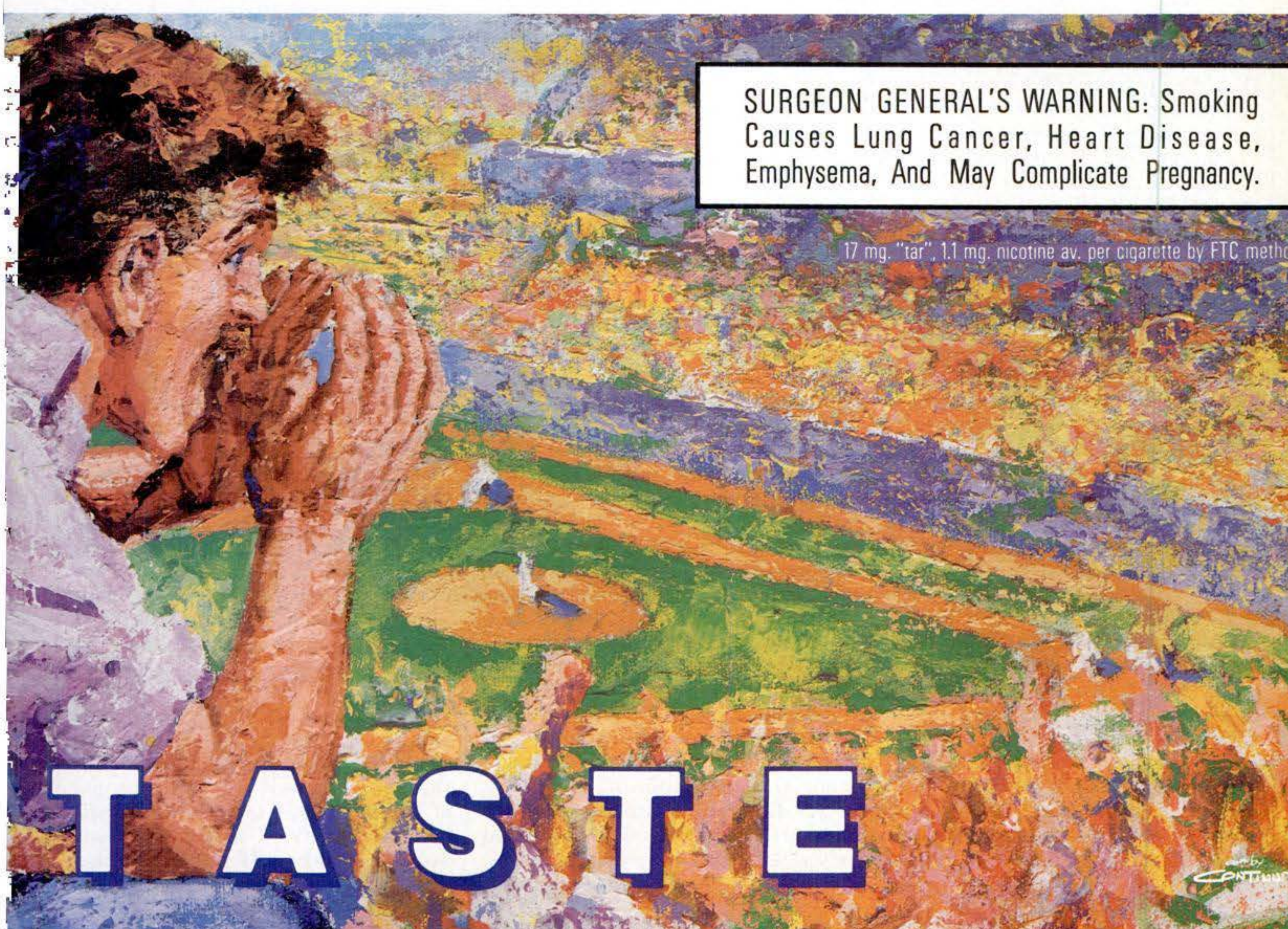
- Maurice Ravel and Sergey Prokofiev conducted their own works of music heard on recordings made in 1928. However, by today's standards, the records were so poor in quality they couldn't be converted into CDs. But the fate of these and other classics are no longer sealed in wax. A digital sys-

tem called NoNoise, developed by Sonic Solution in San Francisco, converts flawed audio into 1,400 megabytes of digital information. Then a computer, taking 8 to 10 hours for every hour of music, processes the data to remove the pop, hiss, and crackle. Ravel and Prokofiev are now available on Philips CDs.

- Evans & Sutherland, best known for making sophisticated flight simulators, used its knowledge of computers to create a parallel supercomputer that performs up to 1.6 billion operations a second. By supercomputer standards, that's about half the speed of Cray's fastest machines, but at \$2.2 million, the new computer's a bargain.

- Attach Phoneguard to your home phone. The result: Callers must dial an access code within 15 seconds of calling your home, or they get a busy signal. The \$250 device, which is made by Breakthrough Electronics Inc. prevents unwanted callers from getting through. Also, according to a spokesman, it can be used to recognize automatically facsimile calls and route them past your phone into a receiving machine.

PS



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TASTE

Home Newsfront

By V. Elaine Gilmore with Gode Davis and Cheryl M. Fiorillo



Rot-resistant "boards" started life as plastic milk jugs. The recycled material is called Durawood, and it comes in several colors and configurations: grooved planks (shown), tongue-and-groove planks, slats, railing, and dowels.

Recycle that jug

Discarded plastic milk jugs contribute 800 million pounds a year to the nation's growing trash heap, according to Chicago-based Eaglebrook Plastics. This company, though, is not part of the problem: It's part of the solution. Eaglebrook buys milk jugs (and other containers made from high-density polyethylene) from community recycling centers, grinds them into pellets, cleans the pellets, then sells them to plastics molders.

A division of the company, Eaglebrook Profiles, is one customer for the plastic granules. Eaglebrook Profiles makes the Durawood plastic planking shown in the photo above.

"Decking, fencing, and landscaping lumber are obvious uses for Durawood," says Eaglebrook president, Andrew Stephens. "It can be nailed, sawed, drilled—nearly anything you can do to wood you can do to Durawood." It's more flexible than wood, however, so when it's used for decking it requires stringers to be more closely spaced (from 12 to 16 inches apart).

It is also more expensive than pressure-treated lumber. "But anybody who has had to replace pressure-treated deck boards because they warped or cracked is not going to shy away from

paying for a good deck that will last forever," says Stephens.

For now, Durawood is sold mostly to manufacturers of other products and to state and local governments. The company hopes to expand into consumer markets, but so far has distributors in only a few areas. And shipping small quantities of the heavy material is uneconomical.

Feds push recycling

As of next February, insulation used in some federally funded buildings must contain a minimum amount of recycled material. The ruling, part of the Resource Conservation and Recovery Act, mandates compliance from any organization or government agency that uses \$10,000 or more a year in federal funds to buy insulation.

The quantity of recycled material required differs by type of insulation: Cellulose must contain at least 75 percent recycled material. With rock wool, 50 percent has to have led a former life. Plastic foams (phenolic and polyurethane) must be from five to nine percent recycled.

What about fiberglass? It is not made with a significant amount of recycled materials, and as far as the Feds are concerned, should be used only where there's no good alternative.

Button up with ZIP

How much insulation would be cost-effective—in your attic, walls, floors, and basement? To answer that you need to consider your climate, the efficiency of your heating and cooling systems, plus the costs of insulation and energy.

Now with a program called ZIP 1.0 to supply most of the data, you can use any MS-DOS personal computer (IBM or compatible) to lead you through the analysis. The program is so named because the data—on climate and regional energy and insulation costs—are gathered and filed according to the first three digits of postal ZIP codes. The ZIP 1.0 program advises on insulation levels for both new and existing houses.

The program was developed by the National Institute of Standards and Technology at the behest of the Department of Energy. MTS Software (3534 Knollstone, St. Louis, Mo. 63135) sells it for \$5. It is also available from the National Technical Information Service, Springfield, Va. 22161. (Call 703-487-4600 for ordering information.)

Chilly heat?

Air-to-air heat pumps and high-efficiency furnaces generally send a higher volume of lower temperature air through the ducts than do less efficient furnaces. Consequently, some people complain that their heat feels like a cool draft.

But a survey in Canada suggests that not many people are troubled. The Ontario Research Foundation confronted 215 owners of high-efficiency gas furnaces and 441 heat-pump owners with this true or false statement: "The heat from the supply registers is often too drafty or too cool." Only nine percent of the gas furnace owners and 16 percent of the heat pump owners checked the "true" box.

Rules for water-heater heating

High-efficiency gas water heaters that supply the family's hot showers are increasingly being channeled to heat the house as well—by piping some of the hot water to a fan-coil unit, through radiators, or tubes imbedded in the floor ["Heat Your House

Continued

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With A Water Heater?" Oct. '86.]

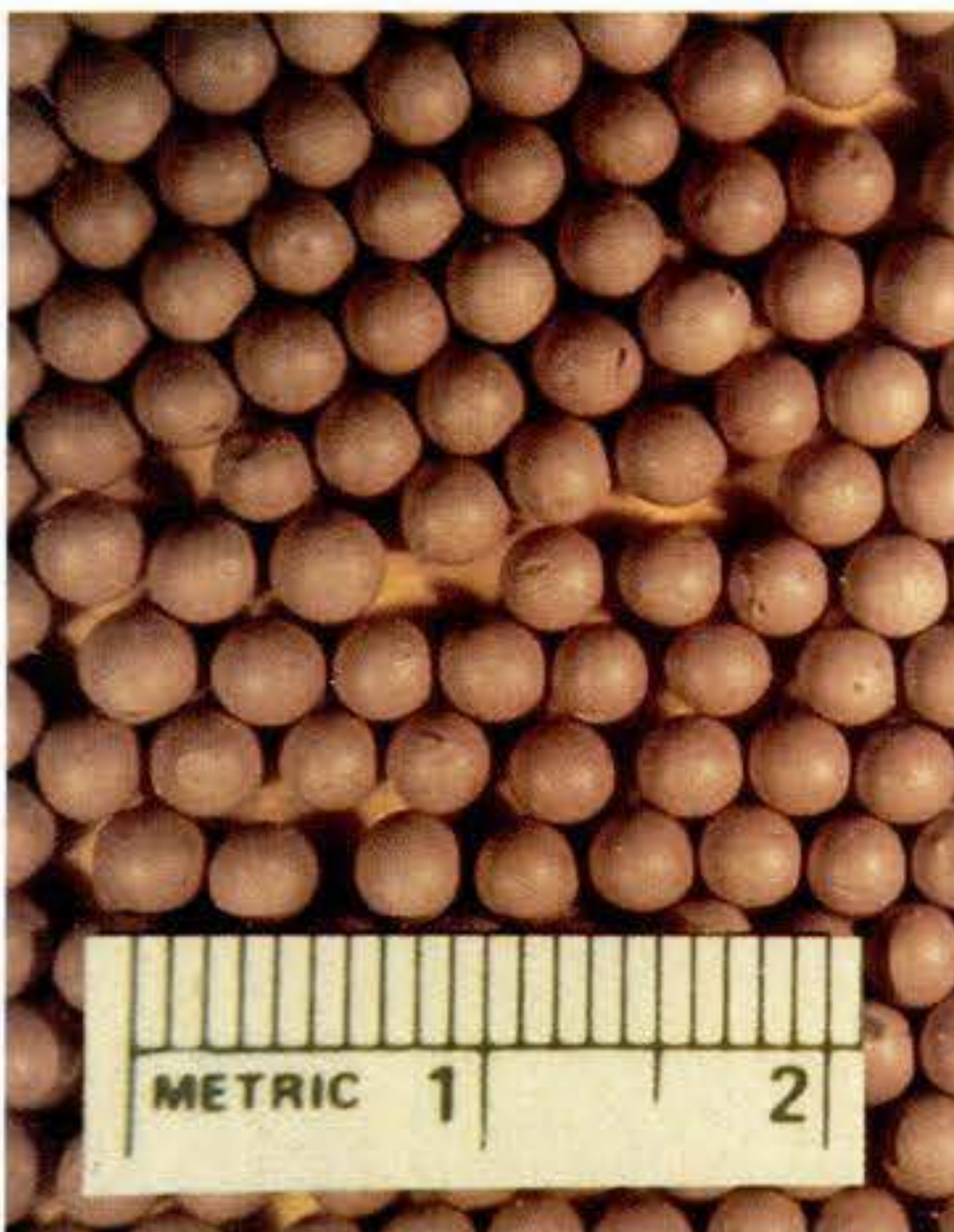
The practice, however, has raised some safety concerns, namely that the potable water might become contaminated or that scalding water might come out of the tap.

Now, the American National Standards Institute has issued regulations that should eliminate these hazards. Under the new rules, a water heater intended for use in a hybrid system must bear the warning that it cannot be connected to an existing hydronic heating system that contains non-potable water. (Often toxic chemicals—antifreeze or cleaning agents—have been added to these systems.)

The new rules also require that all components of a hybrid system be suitable for use with potable water, that toxic chemicals shall not be introduced into a space-heating system that is cross-connected with the potable water, and that a mixing valve be installed to reduce water temperature at the tap if very hot water is required for space heating.

Tiny bubbles

Researchers at the Georgia Institute of Technology in Atlanta have found



Tiny hollow spheres made of ceramic were formed by a process developed at Georgia Tech. They are slated for use in insulation, and can withstand temperatures up to 3,200 degrees F.

a way to make millimeter-size bubbles—thin-wall hollow spheres—from ceramic materials based on a process invented by Dr. Len Torobin of Mineral Technologies. The result is a new insulation that is virtually fireproof,

poses no threat to health or the environment, and can be made of many different compounds to serve different needs. Furthermore, the possible uses go well beyond insulation.

The bubbles, called Aerospheres, have nearly the same insulation value per inch as fiberglass and are similar in density. But they have much higher compressive strength, so they should remain in place without compacting. And while fiberglass insulation starts to burn at 800 degrees F, Aerospheres can withstand temperatures as hot as 3,200 degrees F.

Others have produced *solid* ceramic spheres, according to Georgia Tech ceramics engineers and project directors, Dr. Joe K. Cochran and Dr. Ted Chapman, but a technique for forming *hollow* spheres from powders is an advance.

Aerospheres start as a room-temperature slurry, "simply a dispersion of powders in a liquid," Cochran explains. "That gives us huge flexibility because most solids are available as powders from which we can form a slurry." Inexpensive ceramics like clay, talc, and feldspar are possible raw materials, as are high-tech specialty materials like silicon carbide and silicon nitride.

The slurry and air are blown through a coaxial nozzle to form the bubbles. Then the liquid is removed. (Cochran is cagey about how that's done.) "You're left with powder shells," he says. "And after they're fired at high temperature, the shells are very strong." The hollow spheres have been fabricated with diameters of one to five millimeters, and with wall thicknesses of 12 to 125 microns.

When made for use as insulation, the spheres are formed with solid walls, but they also can be made with porous walls—and used for such things as time-release encapsulants for fertilizers and medicines. Says Cochran: "Since we can control the size of the sphere's pores, we also can control how fast something inside leeches out."

Aerospheres will be put to work first as insulation for high-temperature industrial furnaces. Will they one day be used as insulation in houses? "There's certainly the potential," declares Cochran. "It's strictly a matter of economics: bringing production costs down so that they can compete with existing insulations."—G. D.

Forgiving finish

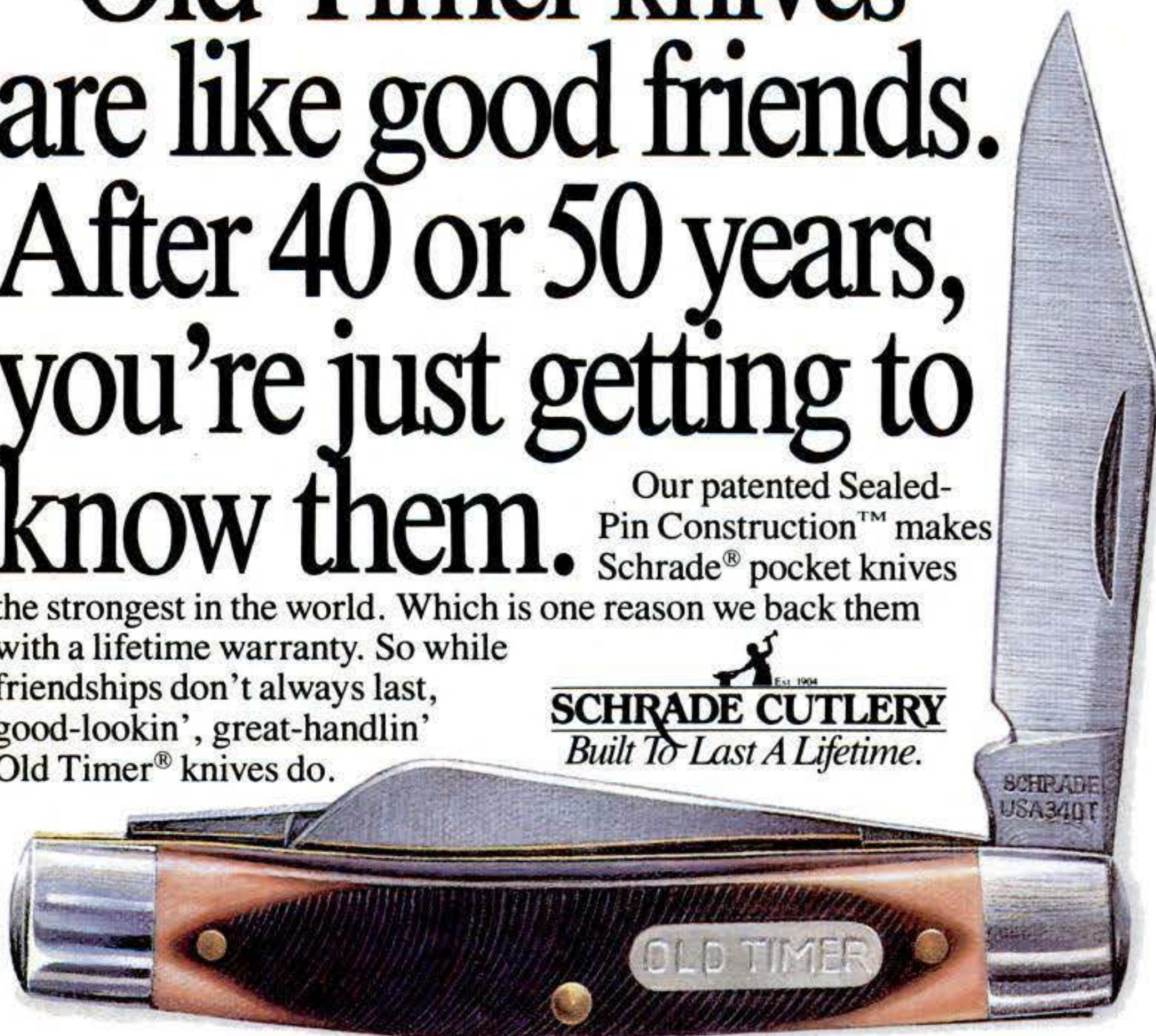
Finishing rough-textured materials can entail a nasty sequence of sand-

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ing, filling, and multiple layers of top coat. Even then you may end up highlighting knotholes, chips, and dents rather than covering them up.

A new product called Texturelac eliminates these problems. All it takes is a standard air compressor (one to three horsepower) and a paint spray gun.

Texturelac creates a pebble-, stucco-, or leatherlike finish depending on how thickly you apply it. It dries to a tough, washable hide, and can be used on virtually any surface: wood, metal, or plastic. Texturelac comes in white and black, and the white can be tinted.

POPULAR SCIENCE Art Director Dave Houser tried Texturelac on an étagère he built from waferboard. Without sanding the rough surface or filling any nail holes, Houser sprayed the shelf unit with one coat of white Texturelac primer. Then he set his compressor gauge at the recommended 70 to 100 psi and adjusted the pressure in both his fluid and air tanks until he got the consistency he wanted. He applied two coats of white Texturelac and ended up with a finish "somewhere between a stucco and a leather," he says. "I was amazed to see that it covered the joined edges without any seams showing."

Texturelac (\$35) and Texturelac primer (\$22) come in two-gallon pails. Thinner (\$13 a gallon) and metal-etching thinner (\$14) are available. The metal-etching thinner prepares metal surfaces so the Texturelac will adhere well. Abilene Research and Development Corp., Box 294, Hewlett, N.Y. 11557.—C. M. F.

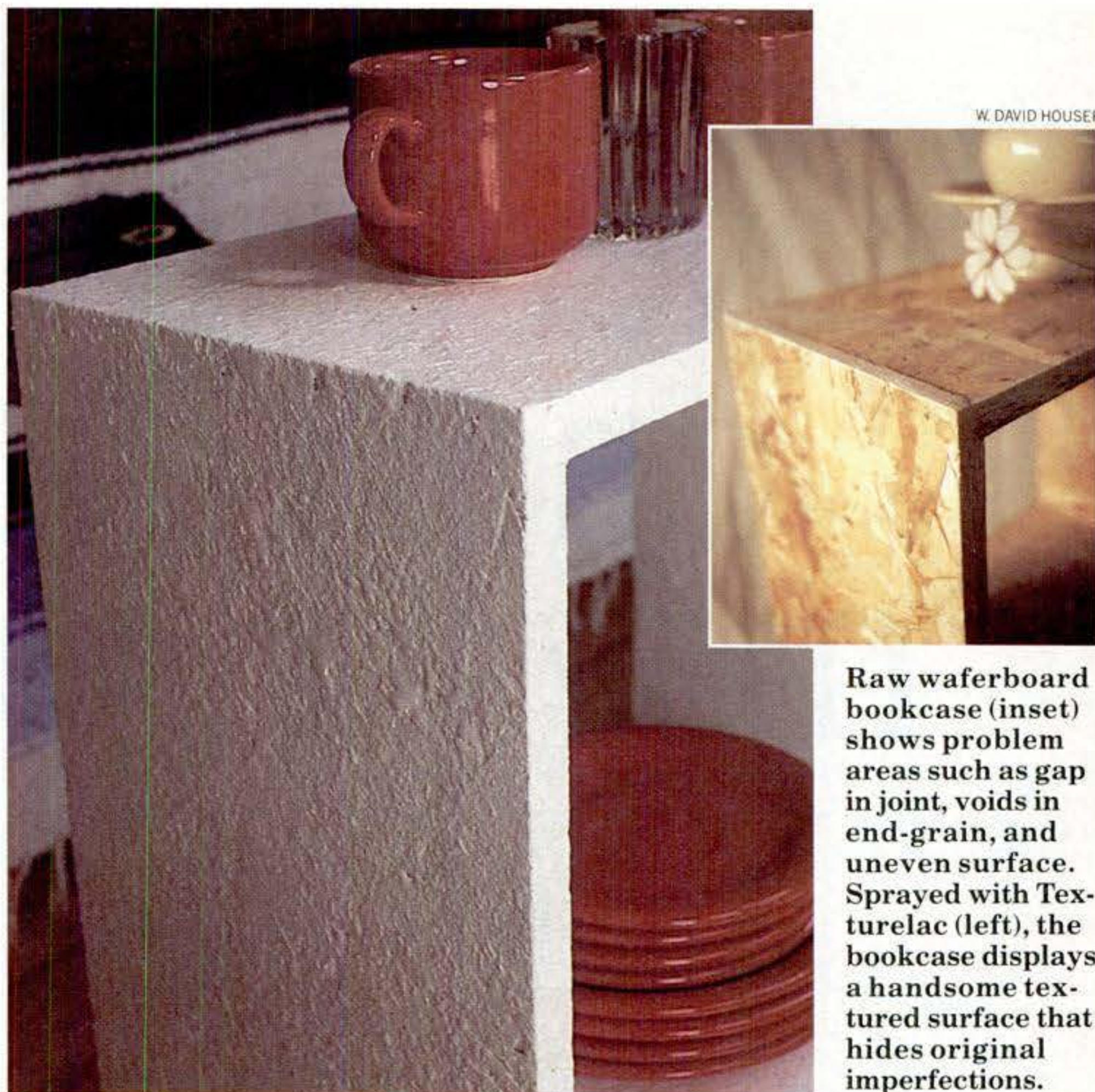
Info mart

If you're shopping for a new refrigerator or freezer, a good place to start is in your armchair—curled up with a copy of the Association of Home Appliance Manufacturers' "1989 Consumer Selection Guide for Refrigerators and Freezers."

The guide lists various types of these cool appliances by cubic-foot capacity and gives the estimated annual operating cost as it appears on the yellow "Energy Guide" label on the appliance.

That energy-cost estimate, however, is based on a 1982 national average of 6.75 cents per kilowatt-hour for electricity. The AHAM guide lists a second yearly energy cost based on 7.70 cents per kilowatt-hour—this year's average.

The guide costs \$1.50 and is available from AHAM, 20 N. Wacker Dr., Chicago, Ill. 60606. **P S**



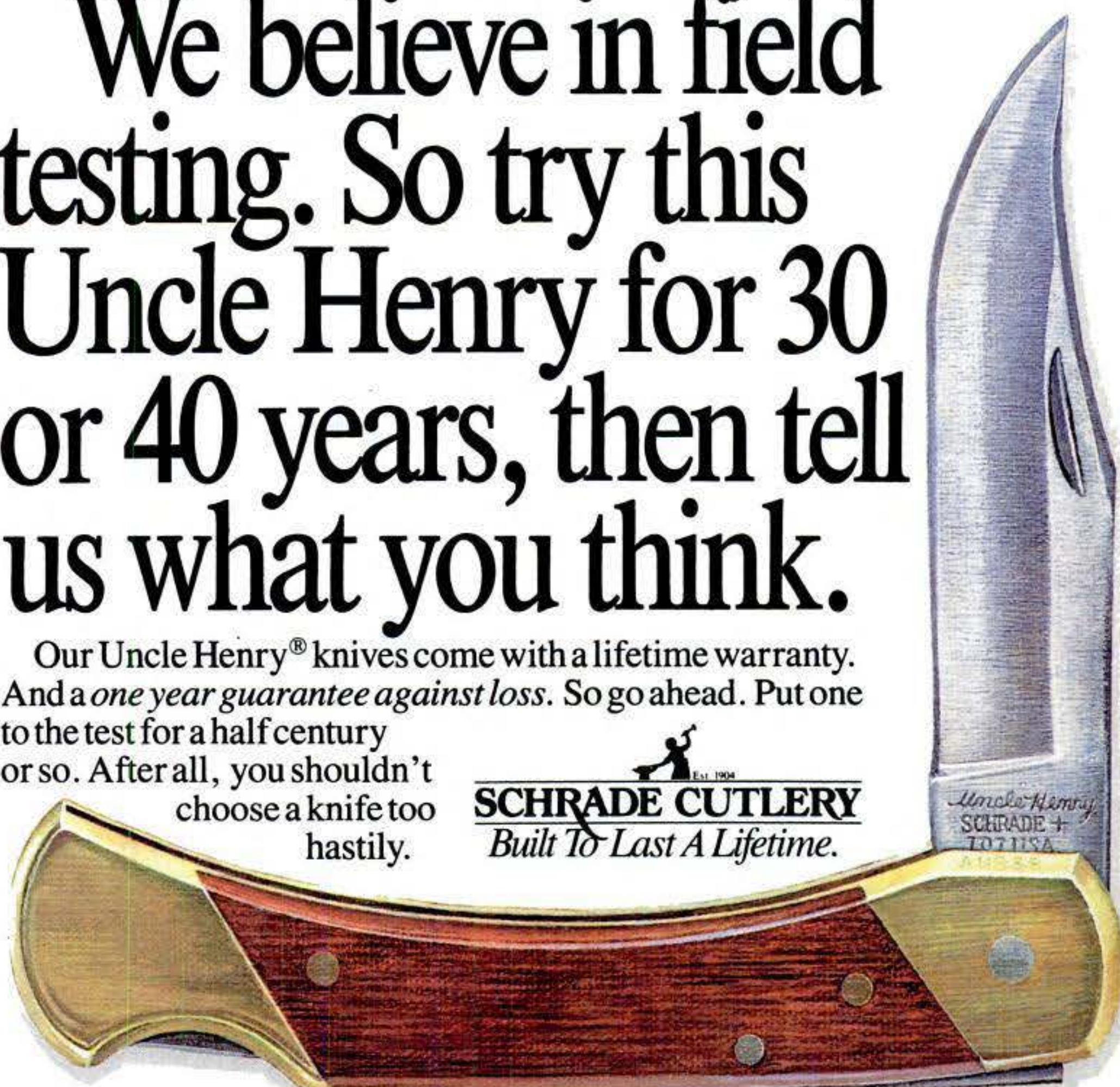
W. DAVID HOUSER

Raw waferboard bookcase (inset) shows problem areas such as gap in joint, voids in end-grain, and uneven surface. Sprayed with Texturelac (left), the bookcase displays a handsome textured surface that hides original imperfections.

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AP/WIDE WORLD PHOTOS

B-2

WHAT STEALTH'S FIRST FLIGHT REVEALS

As the shroud of secrecy falls from the B-2, the U.S. Air Force and Northrop Corp. are trying to convince the country that it is vital to our defense. Congress, on the other hand, is suffering sticker shock and is threatening to cancel the program. The controversy has almost obscured the fact that a clearer picture of stealth technology has finally emerged.

By C. P. GILMORE

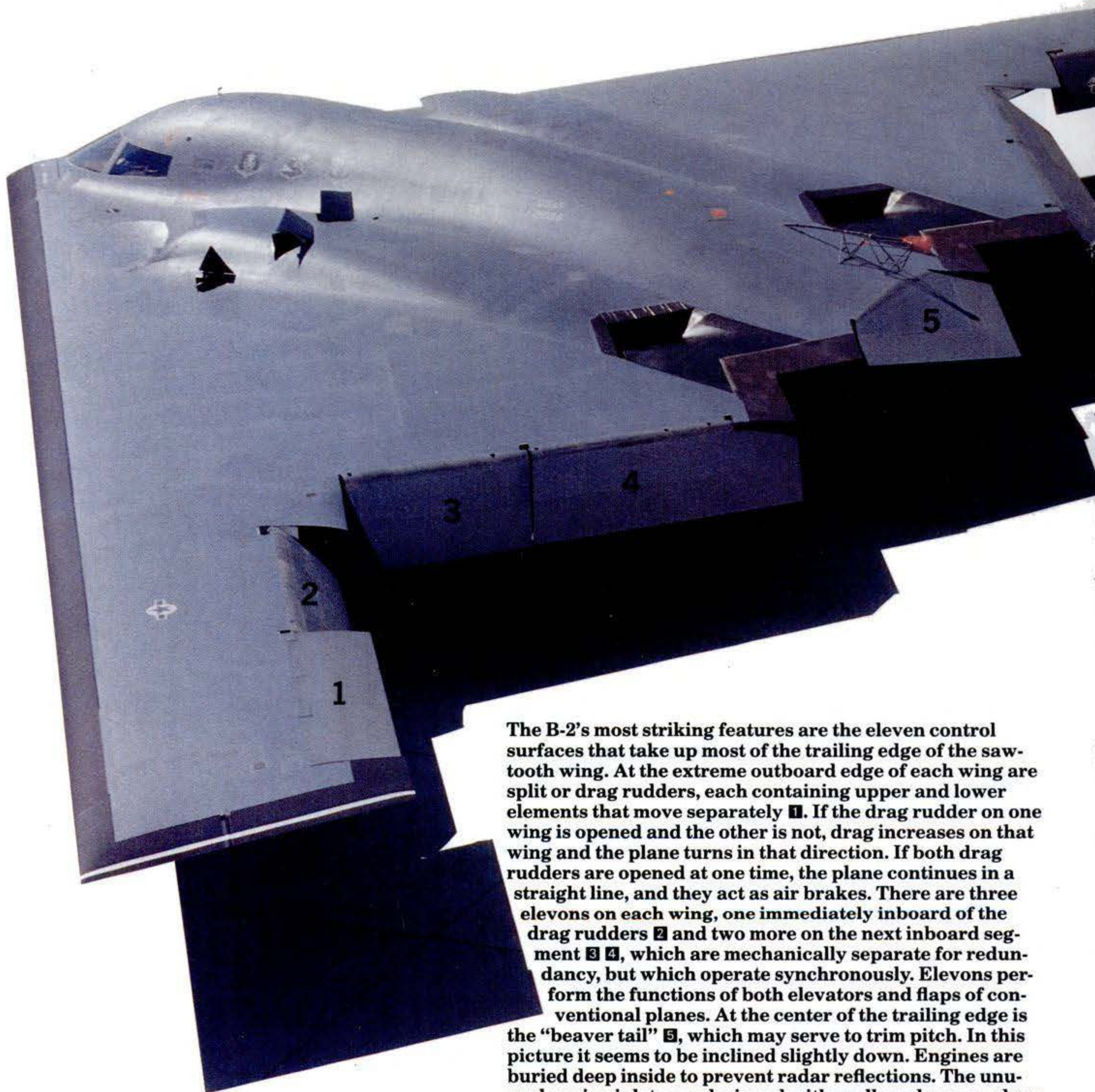
Until now, most information about the B-2—the fabled stealth bomber—was gleaned from a few official announcements, a handful of leaks, and a rigorous application of the laws of aerodynamics and electronics. One observer has called it a “connect-the-dots” approach.

Now, for the first time, we have seen an actual airplane sitting in the sun, taxiing, and flying. Aerodynamicists have analyzed what they’ve seen. Both the U.S. Air Force and Northrop Corp., the manufacturer, are opening up.

Finally, the pilots who flew the B-2 were remarkably candid about the flight and the plane’s engineering. So now, for the first time, we have an accurate picture of this mystery plane and its advanced design.

At the same time, a battle has erupted in Congress. Lawmakers are divided over the B-2’s proposed missions and whether it will be worth the high cost. A lively debate rages over whether the stealth bomber program should be built as planned, reduced in scope, or killed altogether.

Continued



The B-2's most striking features are the eleven control surfaces that take up most of the trailing edge of the saw-tooth wing. At the extreme outboard edge of each wing are split or drag rudders, each containing upper and lower elements that move separately **1**. If the drag rudder on one wing is opened and the other is not, drag increases on that wing and the plane turns in that direction. If both drag rudders are opened at one time, the plane continues in a straight line, and they act as air brakes. There are three elevons on each wing, one immediately inboard of the drag rudders **2** and two more on the next inboard segment **3** **4**, which are mechanically separate for redundancy, but which operate synchronously. Elevons perform the functions of both elevators and flaps of conventional planes. At the center of the trailing edge is the "beaver tail" **5**, which may serve to trim pitch. In this picture it seems to be inclined slightly down. Engines are buried deep inside to prevent radar reflections. The unusual engine inlets are designed with scalloped upper edges of radar-absorbing materials to minimize radar reflections.

Against that background, and whatever its ultimate fate, the B-2 emerges as one of aviation's most fascinating technological accomplishments.

Its pedigree

The most obvious thing about the B-2 is that it is a flying wing, an aerodynamic configuration that has advantages known for decades. John Northrop, founder of Northrop Corp., had been an enthusiast of flying wings since the 1920s and had built several versions. That work culminated in the YB-49 in the late 1940s.

Chief of aerodynamics for Northrop during much of the company's flying wing period was William R. Sears, now professor of aeronautical engineering at the University of Arizona. "Flying wings are very interesting because they offer tremendous advantages not only in aerodynamics, but in structural weight. Instead of concentrating much of your weight at the middle of the airplane, you distribute your load across the span of the wing. This arrangement reduces bending and shear moments, which allows

the designer to build lighter airframe structures."

The B-2 is a classic flying wing. It stands 17 feet high, is 69 feet long, and has a 172-foot wingspan, the same as the YB-49. It has a maximum takeoff weight of 350,000 pounds with a payload of 50,000 pounds (enough to carry 16 nuclear bombs or short-range nuclear attack missiles on two rotary launchers or 80 conventional 500-pound bombs). It is subsonic, and has a ceiling of 50,000 feet. Its four 19,000-pound thrust General Electric F118-GE-100 engines can power the B-2 for 6,000 miles (10,000+ with one air refueling) at 50,000 feet. It has terrain-following capability and systems to suppress contrails to minimize visibility and to cool hot exhaust to avoid detection by infrared sensors.

Little new information is available as to the plane's crucial radar cross section, a measure of its ability to fly undetected by enemy radar. But it is noteworthy that the test model now flying has been fitted with a radar echo-enhancer to make sure ground control radars in Southern California and radars on other planes can spot it.

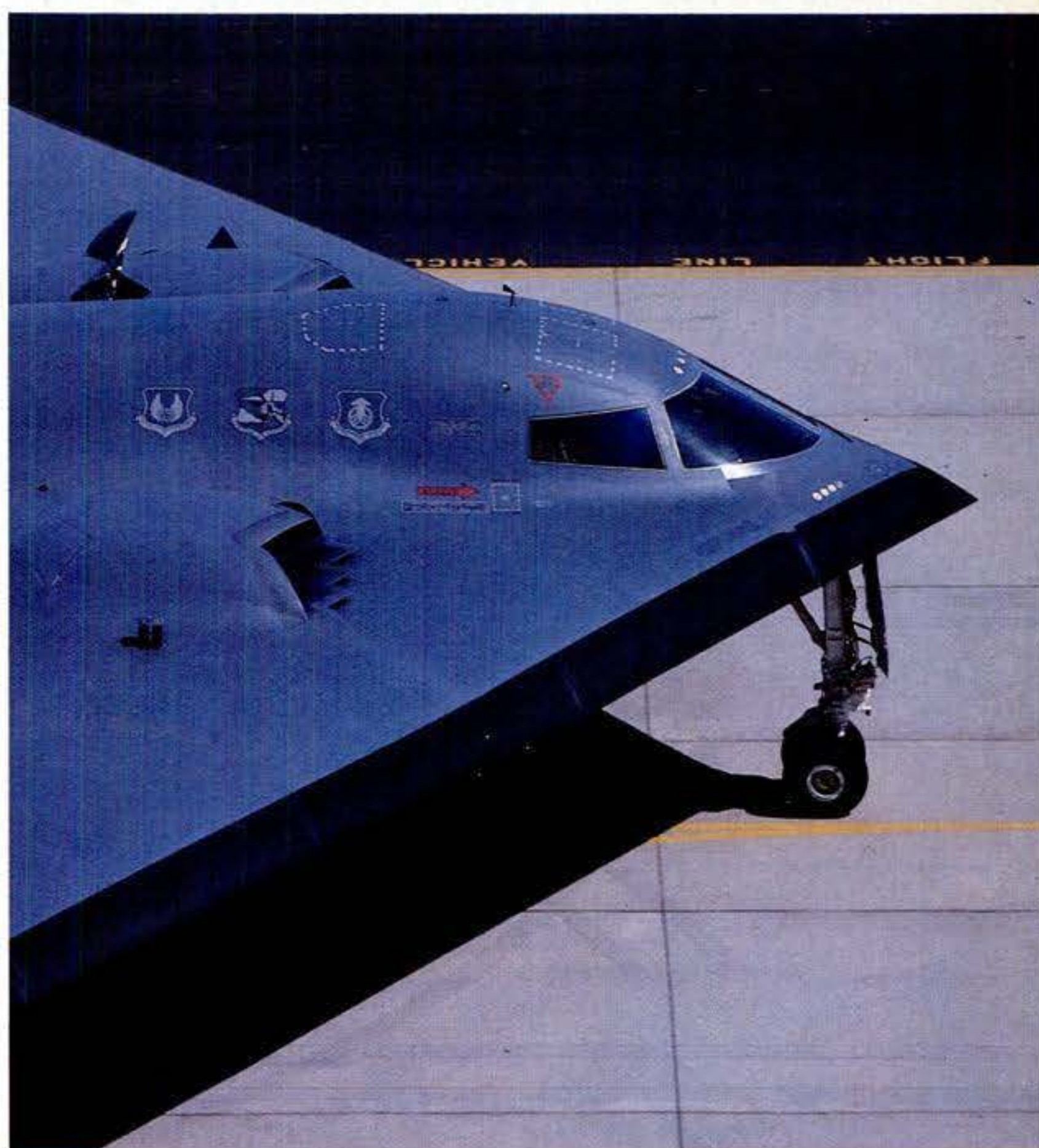
Just ahead of the main inlets are small auxiliary inlets that capture turbulent boundary-layer air that could stall the engines if it were allowed to enter. This cool airflow is mixed with the hot exhaust to make it less detectable by infrared sensors. On top of each nacelle are two pop-up doors—auxiliary engine inlets—pointing forward but angled away from the engine's center line. At the engine's rear, the exhaust outlets are on top of the wing. The V-shaped panels behind the exhaust appear to be the only part of the trailing edge that is fixed. They are said to be heat-resistant ceramic tiles similar to those on the space shuttle. The main cockpit/payload area and the engine nacelles grow out of the wing in complex, hard-to-build curves of constantly changing radius, which are clearly designed to minimize radar reflections. Unlike the F-117A stealth fighter [Jan.], they do not contain facets. The craft has what observers have called a "pregnant" appearance because all weapons, fuel, and avionics are contained inside the shell. The black leading edge, which contrasts with the slate-gray of the rest of the craft, is said to be a radar-absorbent structure that has caused difficulties in design and fabrication. Crew entry is just behind the nose wheel. You can see the edge of a ladder attached to part of the underbody door (upper right). Just outboard of the left engine nacelle is a triangular hole with cover. Puffs of smoke were seen to come from it from time to time; it is apparently the exhaust for the auxiliary power unit. Two "stovepipe" tubes protrude from a similar position outboard of the right nacelle; their purpose is not known. The orange device over the beaver tail is a trailing cone that is reeled out two or three plane lengths behind the craft to provide a reference source for airspeed, altitude, and other data. The small flaglike device on top of the cockpit is a yaw-angle sensor. Experts recognize the landing gear as a modified Boeing 757 or 767 airliner undercarriage.

Would the B-2 actually fly? Some predicted that the inherent instability of the flying-wing design would doom it. "I was amused by that," says Sears. "The engineers knew it would fly. The same thing happened in the 1940s."

The first hint that something important was about to happen came in late June when workers at Air Force Plant 42 in Palmdale, Calif., began sweeping runways and taxiways near Site 4—where the B-2 was under construction—in the early morning hours. Then several groups of 30 to 40 people were seen walking the 12,000-foot runways side by side from end to end, picking up any object that might be sucked into an engine inlet.

At 4:45 on the morning of July 10, Northrop test pilot Bruce Hinds and USAF test pilot Col. Richard Couch started the B-2's engines and performed low-power tests for an hour and 45 minutes before taxiing out onto the runway, where, for four hours, they performed both low- and high-speed taxi tests to demonstrate engine-operating and ground-handling characteristics. On July 13 a second series of taxi tests took place.

NORTHROP CORP./RENPHOT



NORTHROP CORP./RENPHOT

Its first flight was set for July 15, but, as was widely reported, it was cancelled when the pilots got low fuel-pressure readings—a minor problem, easily solved.

Stealth takes off

On the morning of July 17, the B-2 rolled from behind the production building at 5:52. After a series of engine runs and brief taxi tests, the craft stopped in takeoff position on runway 04 at 6:27. Hinds and Couch carefully went through the pre-flight checklist. Then at 6:36 the pilots shoved the throttles forward and released the brakes. As the B-2 began its run, a pair of F-16 fighters streaked down out of the sky and performed what Air Force pilots call a "rolling pickup." Approximately 22 seconds after starting its roll, the B-2 rose rapidly (as shown on the cover). Crowds outside the fences cheered.

The B-2 climbed to 10,000 feet and went through a series of stability and control maneuvers. At 8:29 it touched down at Edwards Air Force Base a few miles away. It was

Continued



Three B-2s under final assembly in Northrop's Palmdale, Calif., plant show the white plasticlike carbon composite outer skin before painting. The protective black mats with yellow markings allow technicians to walk on the curving skin surface without damaging it.

a smooth landing, so smooth that "I had to ask the tower if we were on the ground," Couch quipped later. The chief of the Air Force Systems Command, Gen. Bernard P. Randolph, hailed it as "a historic day."

Hinds, a barrel-chested 50-year old test pilot with 10,500 hours of flying in 66 types of aircraft, appeared at a news conference after the flight. "It flies like a real airplane," he said, and added that it was "very nimble," and "probably better than any large plane I have flown." Sears of the YB-49 team wasn't surprised. "The YB-49 was more maneuverable than a bomber needed to be," he recalls. "They said it would out-turn some then-current fighters."

As to predictions of pitch instability: "The aircraft was very stable: rock stable on final [approach]," reported Hinds. "It took very slight aft stick pressure—just held aft and touched down very smoothly. It's going to be a very easy airplane to fly." Added Couch, "If we appear giggly about all of this, it was kind of fun."

Not all observers were carried away. Rep. Les Aspin, chairman of the House Armed Services Committee, one of those calling for a cutback in the program, called it "a giant leap for Northrop, but one small step for the B-2 program."

What we learned

Since the flight, a steady stream of analysis and new information has come from both the Air Force and independent experts. James F. Marchman, associate dean of engineering at Virginia Tech points out that "The flying wing concept is in many ways the aerodynamicist's dream. The whole airplane is a wing so you don't have to carry around this drag-producing empennage with you." And it works: The journal *Aviation Week & Space Technology* says the lift-to-drag ratio of the older B-1B bomber is be-

tween 9 and 18 in various configurations. Estimated lift-to-drag of the B-2 is 24. That's why it has a 6,000-mile range. "The flying wing is your ideal cruiser-type aircraft," says Marchman.

As for stability problems, they just haven't happened. Lacking a tail, flying wings are unstable in the pitch mode, (movement nose-up or nose-down), but years earlier Sears and his colleagues at Northrop corrected that problem when they installed an automatic stability augmentation system—the world's first—in the YB-49. Now, much more sophisticated electronic flight controls are found on many modern aircraft, including the B-2. These systems, which react faster than pilots can, allow airplanes to fly more efficiently and to maneuver better. "We're using a quadruple-redundant fly-by-wire, digital flight-control system," said Randolph. In such a system, pilots tell the plane what they want it to do by moving the stick. Then the flight computer moves the proper combination of surfaces to achieve the desired effect, while at the same time correcting for wind gusts and other small perturbations.

Aerodynamicists say the outward-pointing doors on top of the nacelles are auxiliary engine inlet doors. They were open most or all of the time the plane has been seen taxiing and in flight. The doors apparently provide cooling air for the engine bays while on the ground, and extra air to prevent stagnation in inlet ducts during low-speed ground maneuvers and perhaps in low-speed flight.

The drag rudders on each wing tip were active during taxiing and flight, indicating they provide what engineers call yaw control—movement of the nose right and left—by introducing drag on one side or the other. During takeoff and approach, both upper and lower sections of the drag rudders were deployed to varying extents, indicating that when both are opened equally they serve as speed brakes or spoilers. The lower rudder is activated first, then, if more control is needed, the top is put into use.

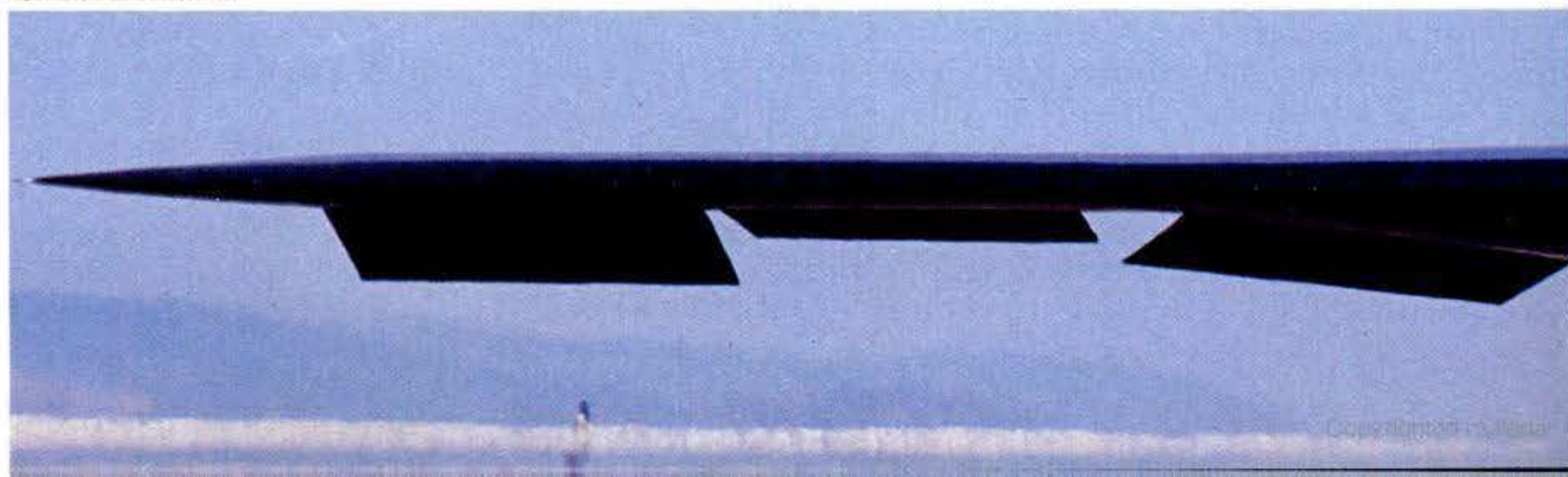
Next to the drag rudders on the same outboard segment of the wing are control surfaces called elevons. "These are flaps that can deflect up or down," says Marchman, "and can be used as flaps or ailerons." On the second main sawtooth section are two additional elevons, which act in sync with the elevons next to the drag rudders. With all elevons operating individually but in a coordinated manner—and with the redundant electronics—control will not be lost if parts of the system fail.

Elevons are apparently used as conventional ailerons to bring the plane into a bank. Although the craft was seen in banks of up to 45 degrees during its flight, it was too far from observers for the actions of the individual elevons to be seen.

At the rear center of the aircraft is a strangely shaped control surface that has been called the "beaver tail." It seems to be segmented and movable, and has appeared to be deflected slightly downward. *Aviation Week* reported that "individuals familiar with the aircraft said the beaver tail is a complex device that required much effort to design." Experts speculate that the center-body surface is used to trim the pitch mode.

The B-2 has an almost sinister air as the ground crew prepares it for flight. The large size of trailing-edge drag rudders and elevons can be clearly seen, as can the vent doors atop the engine nacelles that supply extra cooling air for low-speed operation.

NORTHROP CORP./RENPHOT



Perhaps the most striking feature of the control system is the lack of any vertical surfaces—done, of course, to minimize radar reflections. But this radical arrangement may pay additional benefits. Test pilot Hinds reported that the lack of vertical elements meant that there is little side force, and this would make a crosswind landing simple. He said it would be easy to bring the plane in at a crab angle, then give a final kick to straighten it out just before touchdown.

Concealed turbines

A critical area of design is the propulsion system. The engines must be hidden deep within the fuselage to stop them from sending back radar echoes. That means airflow is hard to handle. The engine inlets have strange, scalloped shapes, apparently to minimize radar reflections. Three openings appear inside. These may be part of a serpentine radar-absorbing structure that pipes in air, but keeps the engine turbine from being visible to incoming radar waves. A thin slit at the bottom, just above the wing, probably admits air that bypasses the engine and then is used to cool the exhaust. That would make it harder to spot with an infrared detector.

The exhaust nozzles are on the top of the wing, also making the hot exhaust more difficult to detect from the ground. The V-shaped surface behind the nozzles looks different from the rest of the wing. Experts speculate it is designed to help reduce the B-2's thermal signature and may be made of something similar to space shuttle tiles.

Northrop developed a sophisticated three-dimensional computer-aided design and manufacturing system with installations in Palmdale at the main Northrop plant, and also at the Boeing Co. in Seattle and the Vought Division of LTV Corp. in Dallas, two of the main subcontractors. Thus everyone was always up to date and changes could be made instantly and simultaneously everywhere. And the plane went directly from the electronic data base stage to the manufacture of production tooling, skipping entirely the usual time-consuming and expensive step of building a full-scale model. The first aircraft built was not a model, but an actual aircraft—the one that flew in July.

The system gives unprecedented accuracy. A precise surface shape was critical to elude radar detection. The new system allowed accuracy to within one-quarter inch from wing tip to wing tip—many times more accurate than any other plane ever built. Even complex items like tubing that had to snake through the structure were manufactured with computer-guided bending machines, then put directly in place. Randolph said the advanced system produced remarkable results: a six-to-one reduction in first-fit problems, a 90-percent success rate on first installation of tubing, compared with an industry average of 60 percent.

Stealth's first battle

"Until recently," reported the journal *Science*, "the layers of secrecy have shielded the program not only from public scrutiny but also from the criticism that has been directed at virtually every other major weapon system." No more.

Now the B-2 is attracting heavy flak from critics both inside and outside of Congress. The main criticism involves two areas: missions and cost.

The U.S. Department of Defense has for many years built its strategy on the so-called "triad"—ICBMs, submarine-based missiles, and manned bombers. Bombers can be sent out in case of a war alert, then recalled hours later if necessary—whereas missiles cannot. But why, with the current B-52s and the growing B-1B fleet, do we need another bomber? Gen. Larry Welch, Air Force chief of staff, says that in case of nuclear war, the B-2 would eventually be able to slip unobserved into an enemy nation to knock out so-called "relocatable" targets—missiles mounted on rail cars, for example. It could also destroy hardened underground command centers. Welch and other military experts say manned bombers are crucial for these assignments and can do the job more accurately than can any other methods. The rationale is that the Soviets would never risk a first strike if they were convinced that the B-2 would come in afterward and destroy its reserve mobile forces and the bunkers housing the military and civilian leaders. The B-2, says Secretary of the Air Force Edward C. Aldridge Jr., "essentially renders Soviet radar ineffective." "We've already done that with the air-launched cruise missile," counters Michael Brower, an arms analyst for the Union of Concerned Scientists. "There's no effective defense against ALCMs, except for some point targets. And cruise missiles are only going to get better."

Secretary of Defense Richard Cheney disagrees. He claims that we "will begin to find it increasingly difficult to penetrate Soviet air defenses over the next ten to twenty years with the systems we now have in place. The B-2 is required to maintain the effectiveness of our penetration bomber force as Soviet air defenses continue to improve."

Conventional role

Randolph makes another point: "Remember the Libyan raid?" he asks. "Do you realize we used something like one hundred combat and support airplanes in that raid? And yet if we had the B-2, three or four flying from the United States using one or two tankers could have done it with complete surprise. That's the kind of thing we're talking about in terms of conventional capability." Nonsense, say the critics. The U.S. would never send a half-billion dollar airplane to teach a minor dictator a lesson and risk losing it—particularly in a place where the Soviets might get to look at it if it went down.

Controversy rages on every point. Sen. Sam Nunn, a B-2 supporter, says it will cause the Soviets to spend a pot of money on new air defenses, which reportedly have already cost \$300 billion to \$400 billion. "They would have to revamp their entire radar and fire-control system," he says. "They are going to have to spend several hundred billion dollars—far more than the cost of the B-2—to defend against it." Brower disagrees: "I don't think you can make that case," he says. "The amount the Soviets spend

[\[Continued on page 90\]](#)



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P A R T T H R E E

SAVING THE PLANET

“We believe that global environmental change may well be the most pressing international issue of the next century.” That is the conclusion of the presidents of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. Central to that issue is the role of society in contributing to global warming by enhancing the greenhouse effect. But how best to limit the pace of global warming and cope with its consequences is already the subject of furious debate over choices. Cut down on fossil fuels? Go nuclear? Plant more trees? Paths to the future are mired in uncertainty.

By ARTHUR FISHER

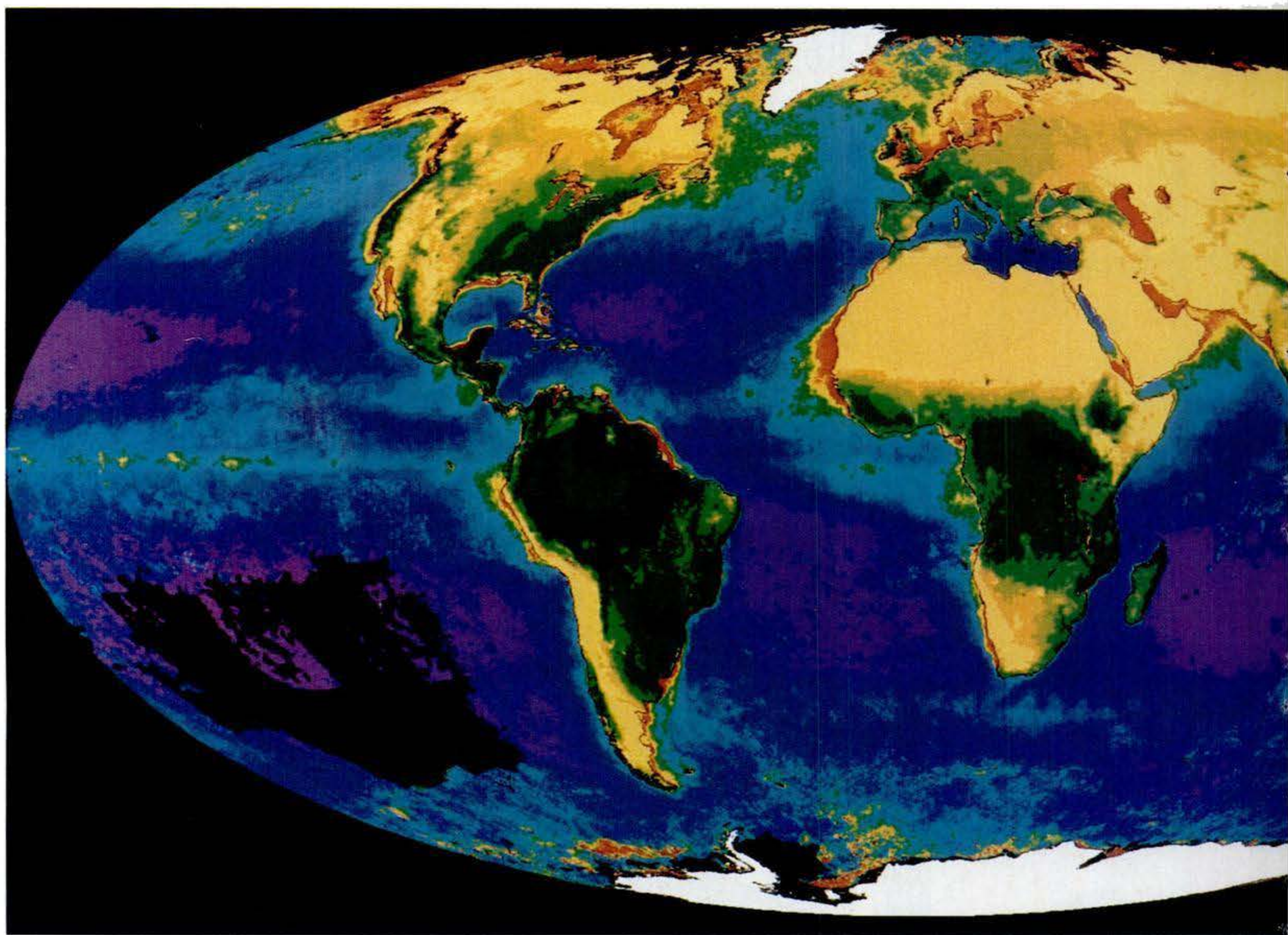
DRAWINGS BY BOB LANGE

How shall we save the planet from an escalating greenhouse effect? There is certainly no shortage of suggestions:

- Orbiting umbrellas. Seed the skies with thin, opaque space shields that would partially block incoming sunlight, thus helping to keep global temperatures down. If these shields had a combined surface area equal to two percent of Earth's, they could counteract a doubling of atmospheric carbon dioxide.

Continued

GLOBAL WARMING



- Disrupt molecules of atmospheric chlorofluorocarbons, some of the most potent greenhouse gases, by blasting them with intense infrared beams from giant Earth-based lasers à la Star Wars.

- Launch an armada of solar power satellites, converting sunlight to microwave power that could be beamed down to Earth and turned into electricity. The vast power made available in this way would free society from much of the need to burn fossil fuels, and drastically reduce the quantity of carbon dioxide spewed into the atmosphere.

- Duplicate the cooling effect of volcanic eruptions, which belch millions of tons of sulfur dioxide into the upper atmosphere, where the compound forms sulfuric acid. The acid acts as a baffle to block sunlight. Hundreds of jumbo jets could deliver the requisite 35 million tons of sulfur dioxide per year to the stratosphere.

- Trigger a population explosion of

phytoplankton, microscopic algae that dwell in the oceans and absorb carbon dioxide in the solar-driven process of photosynthesis. Their blooming could be stimulated by fertilizing their environment with phosphates. Or huge orbiting reflectors could divert sunlight to the polar seas, otherwise dark in winter.

Projects such as these, so spectacular in scale, smack of science fiction. They would be dogged by questions of economics—staggering sums would be required—practicality, and (ironically) environmental impact. For example, four million space shields would have to be built and launched. Powerful microwave beams might have unanticipated and unpleasant effects on planes passing through them and on people on Earth. Adding more sulfuric acid to the atmosphere would cause more acid rain to fall. And so on.

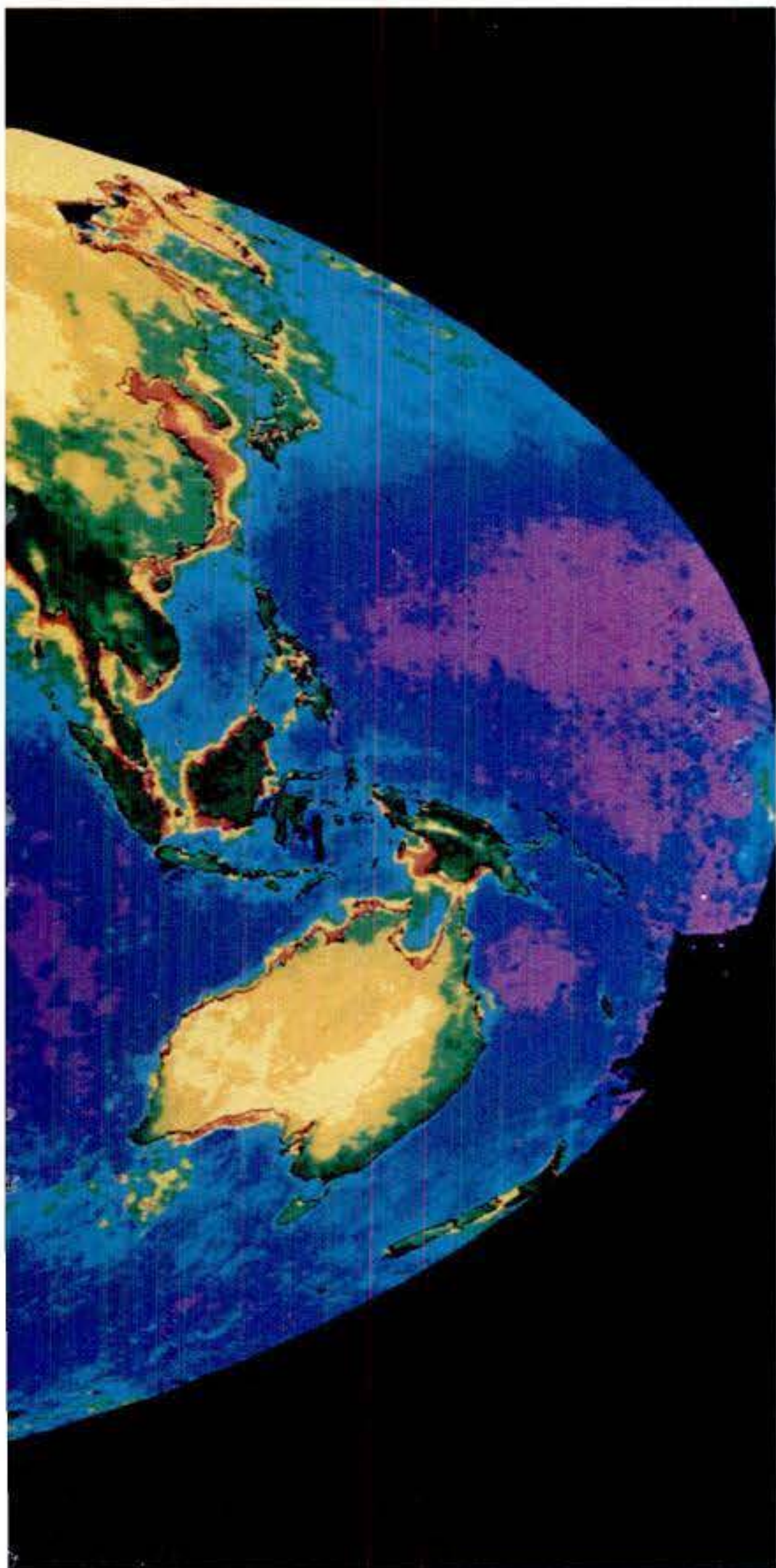
Yet these fantastic fixes are the serious, considered proposals of highly respected scientists. Credit a number

of space scientists with the orbiting umbrella idea; Princeton physicist Thomas Stix with laser zapping CFCs; Peter Glaser of Arthur D. Little, Inc., with solar-power satellites, first proposed in the 1970s (“We must begin to develop alternatives to burning fossil fuels now, while we still have time to do so,” says Glaser today); Wallace Broecker, a geochemist at Columbia University, with the volcanic approach; and dean of climatologists Roger Revelle, now at the University of California, San Diego, with the phytoplankton proposal.

That these esteemed—and very practical—scientists would consider such extreme measures to counter global warming is a measure of the gravity of the problem they foresee. If more conservative steps are not taken now, or if they fail, radical ones may be necessary a century from now.

“The point is not that the strategy

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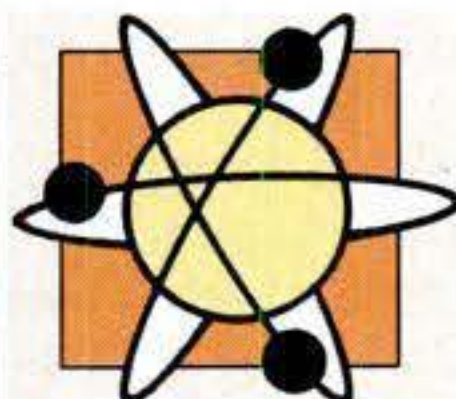
Some of the additional knowledge needed by climatologists to better understand the global warming problem will stem from NASA's proposed Mission to Planet Earth ["Is the U.S. Lost In Space?" July]. This image illustrates the kind of data that mission could bring. It is the first ever of the total global biosphere, showing the intricate distribution of life forms on the continents and in the oceans. The image was assembled by NASA's Goddard Space Flight Center from two sets of satellite data: from the Nimbus 7 (for the oceans) and NOAA 7 (for the land) spacecraft.

In this color-coded image, red and orange in the oceans show high levels of phytoplankton, which absorb CO₂; yellow and green show medium levels.

In the land mass image, the darkest greens denote tropical forests, a shrinking source of CO₂ takeup. Regions with sparser biomass show up in lighter greens. Barren stretches and deserts are yellow.

HOW TO HELP REDUCE GREENHOUSE GASES

Controlled thermonuclear fusion would be the ne plus ultra of alternative energy sources: It not only generates no CO₂, but does not have the radioactive waste disposal problem of fission energy. One cubic foot of sea water could furnish the energy in 10 tons of coal—an inexhaustible supply. Nuclear fission is now the largest source of energy that does not result in CO₂ emissions. Global electricity production from nuclear plants grew by five percent in 1988 with 17 new units. Plans for a new generation of reactor designs are being considered, including Argonne Laboratory's Integral Fast Reactor, a breeder; Switzerland's Geyser Reactor; and the Electric Power Institute's Advanced Light Water Reactor.

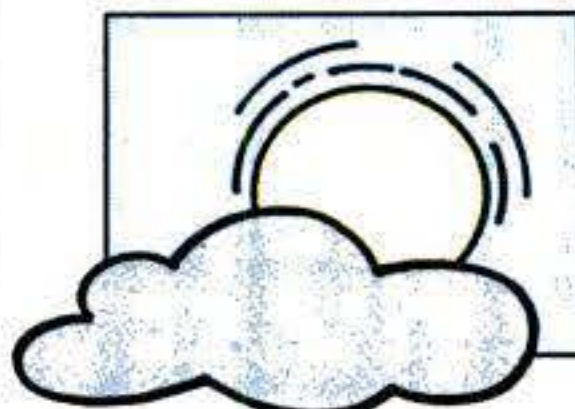


NUCLEAR

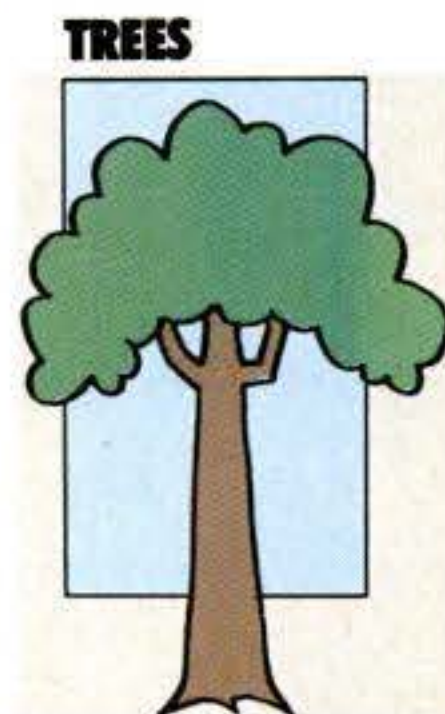


FUSION

Trees are nature's way of helping to balance the carbon dioxide equation; the world's forests absorb massive quantities of the gas from the atmosphere during photosynthesis, the process by which green plants manufacture carbohydrates. Halting the destruction of tropical forests and planting more trees is a double-edged weapon against CO₂. In a report on global warming, the EPA recommended planting at least as many trees as are felled.



SOLAR



TREES

The EPA also proposed increasing research on solar energy so that this relatively benign source could compete economically with oil and natural gas. Not all solar energy systems rely on photovoltaic cells (which convert the sun's rays directly to electricity).

Solar thermal systems convert sunlight to

heat, which can either be stored or used to drive a turbogenerator.

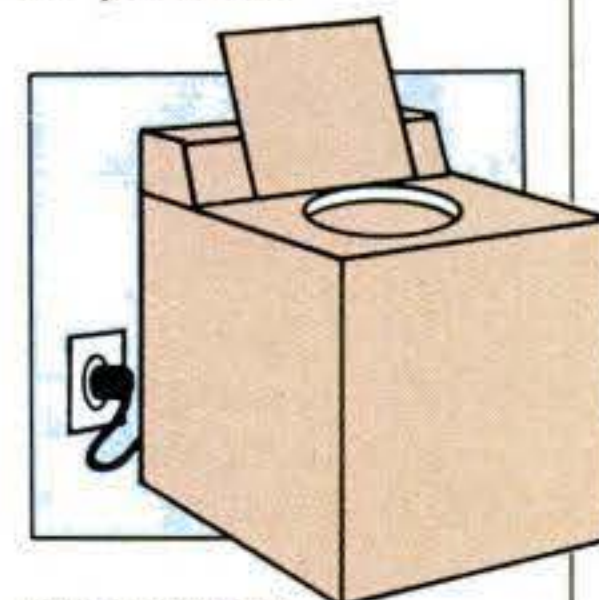
Federal funding for solar research is \$35.5 million per year; it was \$155 million in 1981. The administration wants to cut it 30 percent. Electric utilities are searching for ways to generate and distribute electric power more efficiently. By one estimate, for example, the energy lost in distribution transformers alone amounts to 50 billion kilowatt-hours a year in the United States, enough to power six million homes and worth \$4 billion. If the cores of those transformers were replaced with metallic-glass alloy, the savings in annual energy loss would be almost 70 percent.

Global warming will increase the need for electricity, and shortages are likely. More efficient appliances can help. New federal standards for new major appliances including refrigerators, dish and clothes washers, freezers, water heaters, gas ranges, and furnaces could save more than 30 trillion watt-hours of energy by 1995, according to the American Council for an Energy Efficient Economy (ACEEE). Refrigerators alone

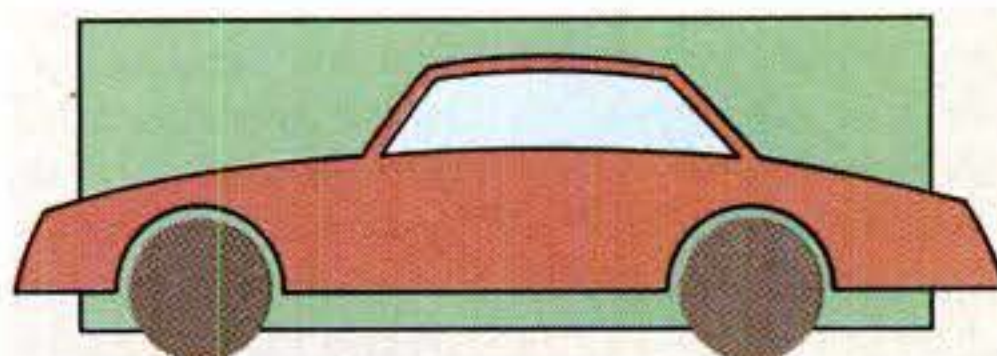
use seven percent of the whole U.S. electricity output. If every refrigerator were of the most efficient variety, the energy savings could be equivalent to the output of 12 large nuclear plants, says the ACEEE. The EPA advocates an international program to ensure that all new automobiles produced anywhere in the world have a fuel economy of 35 mpg, and

that all cars in industrial countries have catalytic converters to control exhaust emissions. Bills introduced in Congress would be even more stringent.

ELECTRICITY



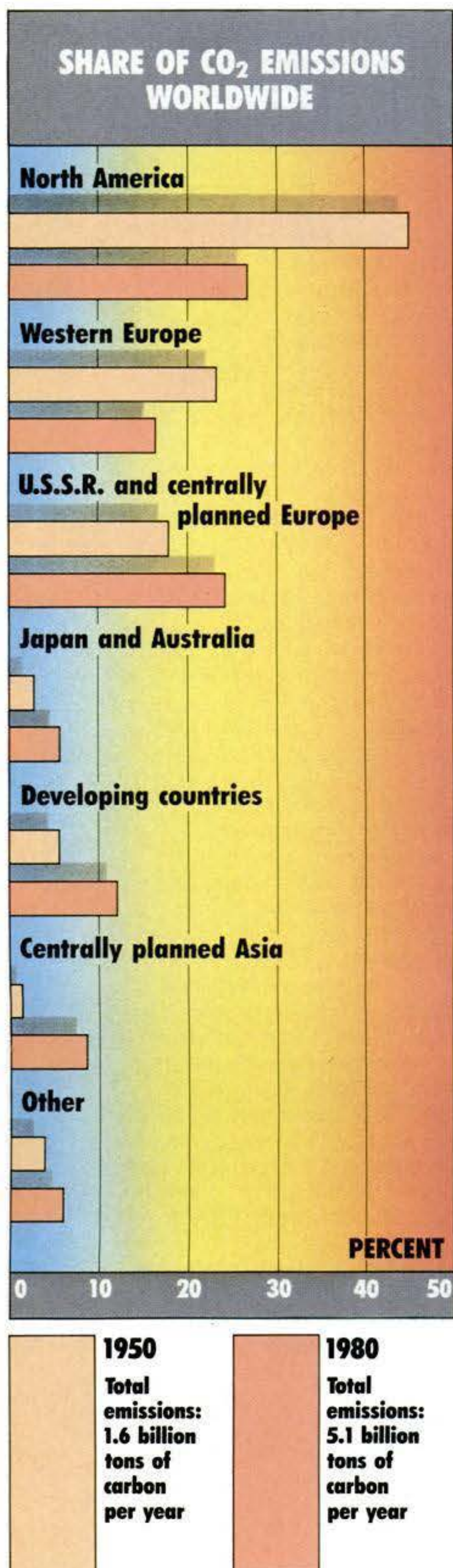
APPLIANCES



AUTOMOTIVE

DRAWINGS BY TOM WHITE

GLOBAL WARMING



is necessarily a wise one," Broecker wrote in his book *How to Build a Habitable Planet*, "but that purposeful global climate modification lies within our grasp."

Many scientists from many disciplines now believe that such modification is imperative, and the sooner the better.

What means does society possess to counteract global warming due to an enhanced greenhouse effect?

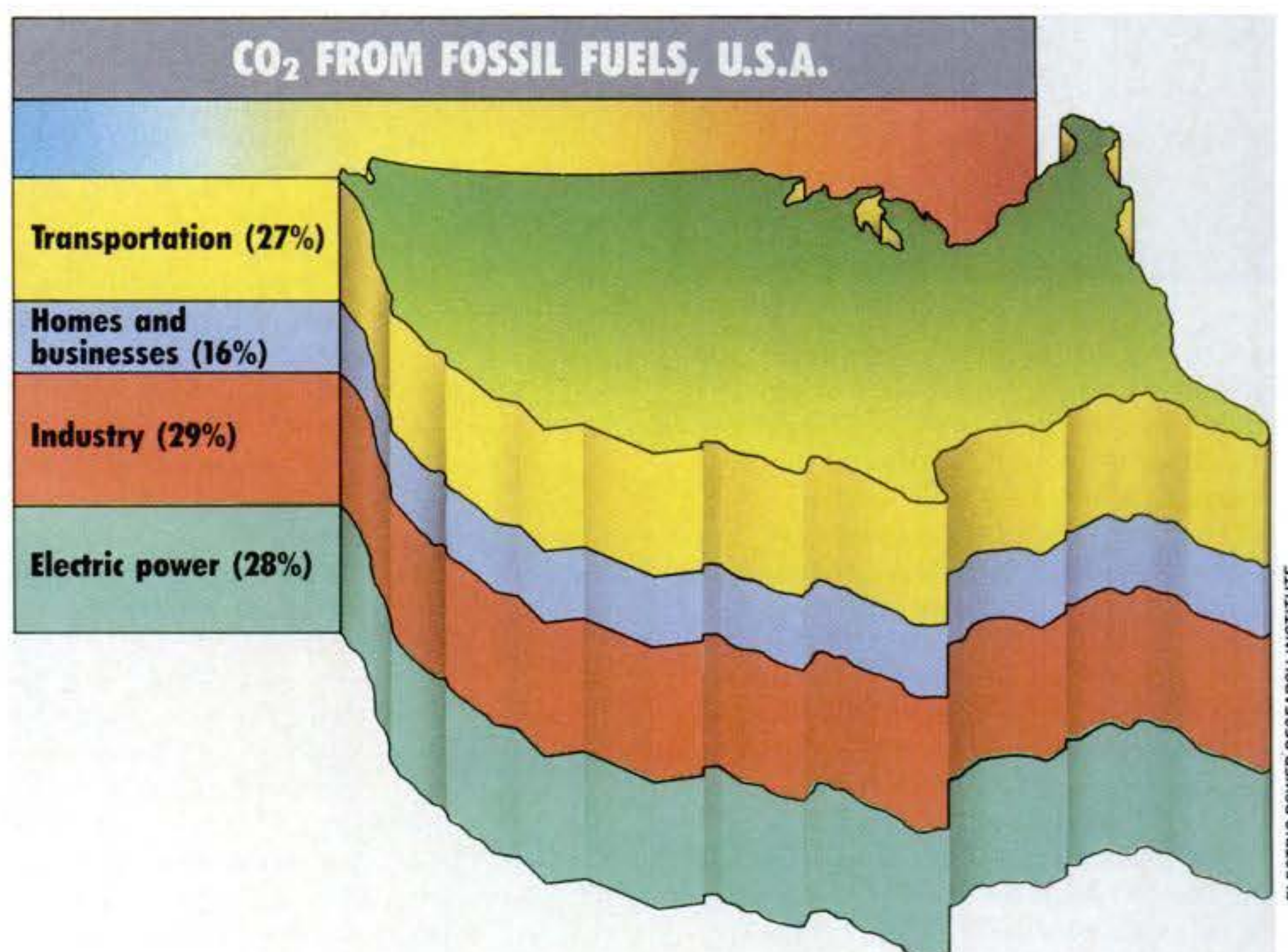
Since carbon dioxide now accounts for about half of all the temperature-raising contribution of the greenhouse gases, one obvious route is to limit its generation. That means curbing the burning of the fossil fuels, either by shifting to alternative energy sources that do not produce the gas; or by making the use of energy more efficient so that less would need to be generated—energy conservation; or by some combination of the two.

Even shifting from one fossil fuel to another less offensive would be an improvement. Brookhaven National Laboratory has ranked different fuels by their greenhouse gas contribution, when burned, in pounds of carbon di-

oxide generated per million Btu of heat. Natural gas is at the low end of the spectrum, at 0.11. Oil is at 0.16, wood at 0.18, and coal at 0.20. Therefore coal-burning power plants are 25 percent worse than oil-burning plants with respect to greenhouse gas production.

The other side of the carbon dioxide equation is to increase, or at least stabilize, its absorption from the atmosphere. A practical step in that direction (more practical than, say, stimulating the growth of phytoplankton) is to stop denuding the world's forests. This move would have other dividends. When trees are felled and burned, the combustion process feeds both carbon dioxide and methane to the atmosphere. And, as detailed in Part II [Sept.], the cattle established in cleared areas of tropical forests contribute their own substantial measure of methane, as do the termites that find felled trees particularly congenial.

Third World countries are beginning to recognize that they have a stake in preserving tropical forests. But there is a residue of resent-



Carbon dioxide emissions from the world's nations more than tripled from 1950 to 1980, from 1.6 billion tons of carbon per year to 5.1. The increase results from the growth of industrialization, whose changing pattern has also altered the pattern of global carbon contributions. North America and Western Europe together accounted for 68 percent of the CO₂ in 1950, but only 43 percent of the total 30 years later. But the portion from China and developing countries in Africa, Latin America, and southern Asia grew from 7 to more than 20 percent of the world total.

About a quarter of the world's carbon dioxide emissions stem from the combustion of fossil fuels in the United States. This share is attributable in roughly equal proportions to industrial processes, such as aluminum and steel processing; electric power production; and all modes of transportation. Energy expended in the nation's homes and businesses plays a somewhat smaller role. About 80 percent of the electric power generated in the United States comes from burning fossil fuels, primarily oil and coal. It accounts for some 7.5 percent of the world's total CO₂ emissions.

GLOBAL WARMING

ment at what is perceived as a holier-than-thou attitude on the part of the developed countries. In March the eight nations of the Amazon Pact—Brazil, Bolivia, Colombia, Ecuador, Guyana, Peru, Surinam, and Venezuela—condemned foreign pressures to save the rain forests as outside interference in domestic environmental policies, and stated they would not accept “impositions from people who try to boss us around.”

The need to embark on measures to control the greenhouse effect has now been recognized not just by climatologists and ecologists but belatedly by some government leaders. Last July the heads of seven major industrial powers (Britain, Canada, France, Italy, Japan, West Germany, and the United States) met in Paris for an economic summit. For the first time as a group, they acknowledged the need to cope with a variety of environmental onslaughts, with special emphasis on global warming.

A communiqué issued by the sum-
miteers stated: “Scientific studies have revealed the existence of significant threats to our environment....

“Decisive action is urgently needed to understand and protect the Earth’s ecological balance....”

Although the seven nations together contribute some 40 percent of the CO₂ generated by the burning of fossil fuels, they offered no binding proposals, but stated that they “strongly advocate common efforts to limit emissions of carbon dioxide and other greenhouse gases, which threaten to induce climate change, endangering the environment and ultimately the economy.”

The communiqué cited deforestation as a contributing factor to environmental change, recommended greater efforts toward energy conservation, and gave the nod to nuclear power.

And in reference to the difficulty of using climate models to make sure and certain projections into the future, the seven stated “the persisting uncertainty on some of these issues should not unduly delay our action.”

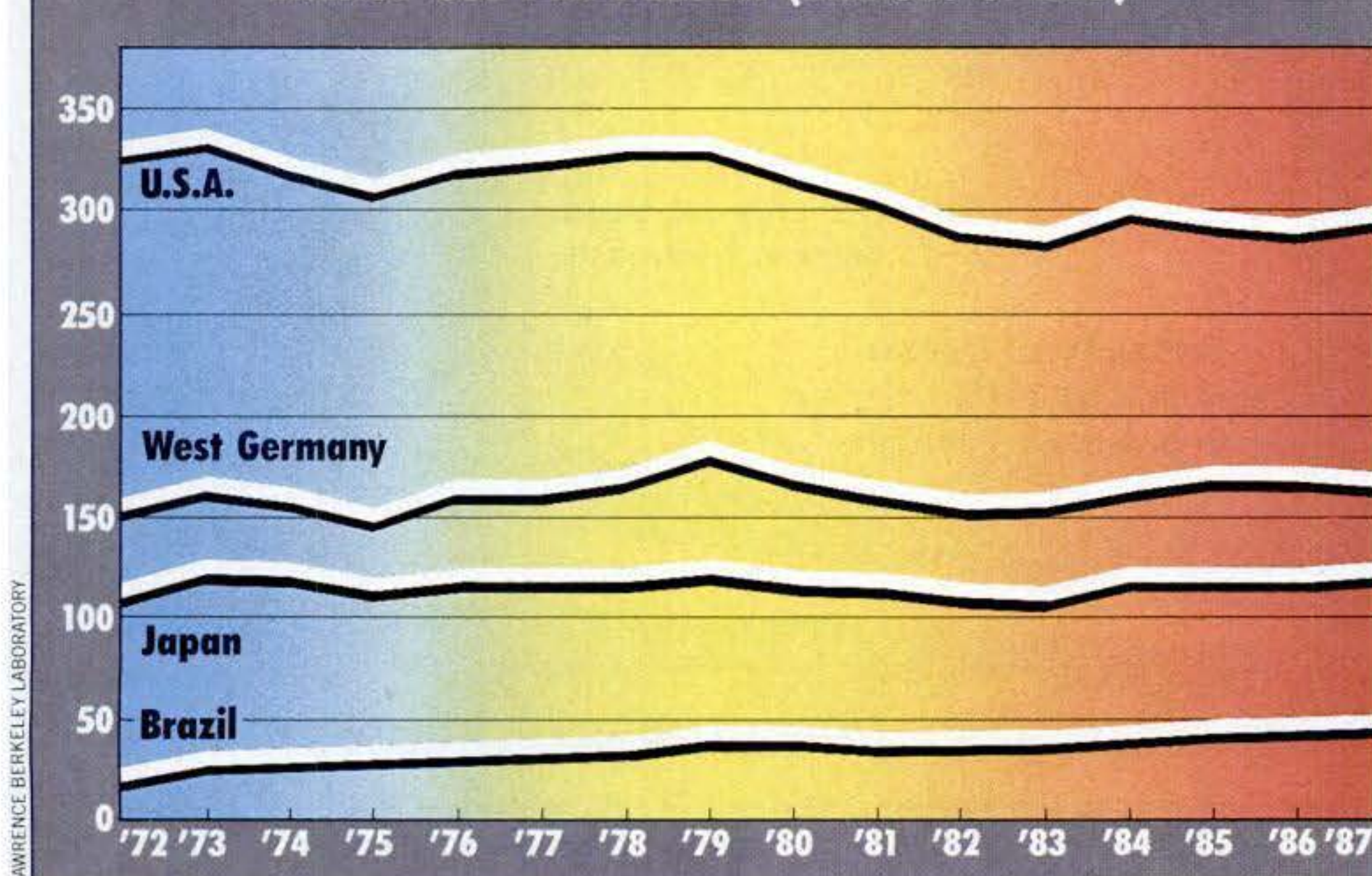
More easily said than done. The potential impacts of major changes in

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CO₂ EMISSIONS PER PERSON



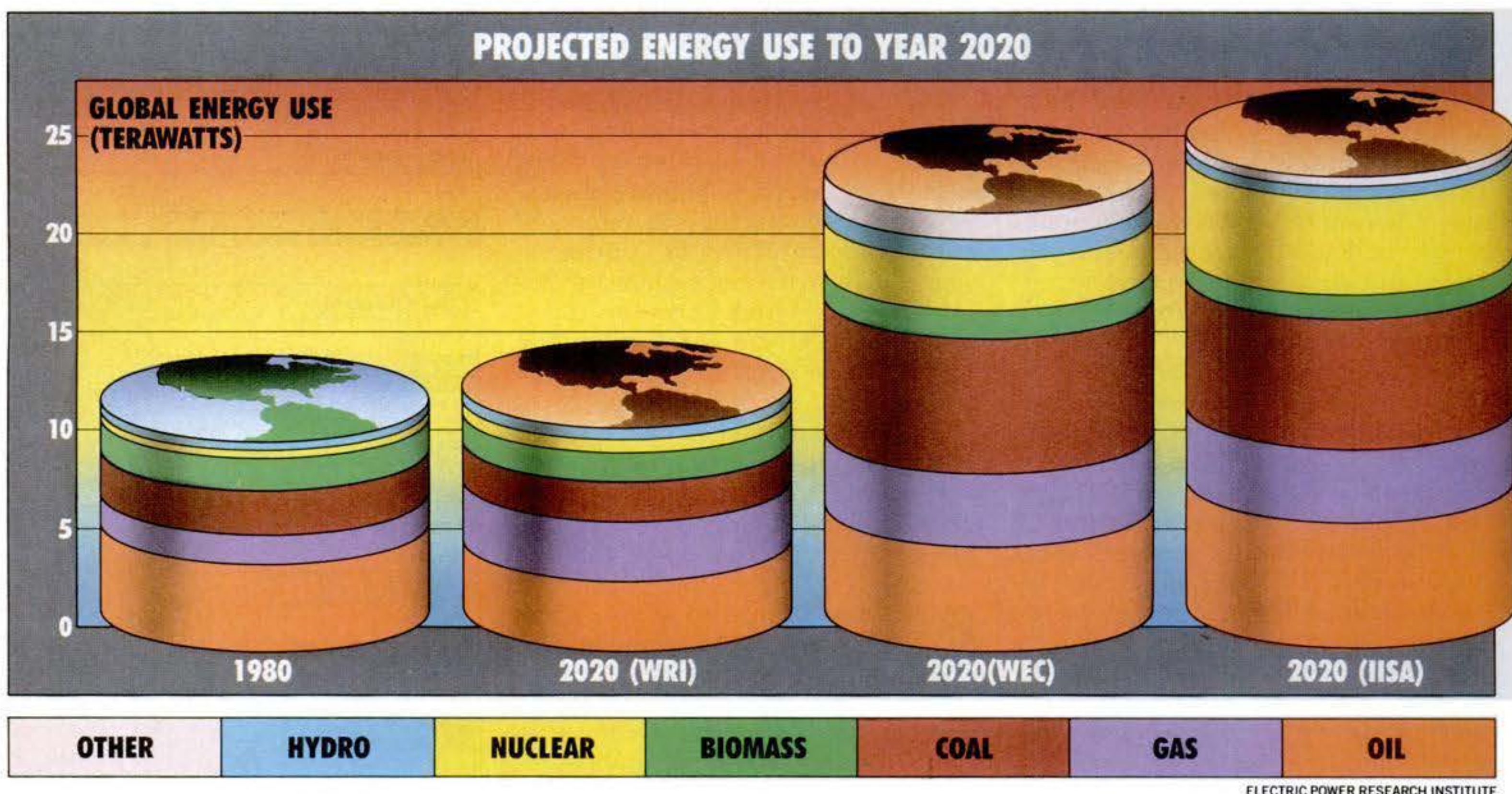
ENERGY USE PER PERSON (millions of BTU)



The United States is far more profligate with energy than other countries, including such highly industrialized ones as West Germany and Japan, as shown in the energy use per capita chart above. Japan requires half as much energy to provide the same amount of goods and services as we do, and West Germany a little more than half. Part of this difference comes from differences in living standards; Japanese refrigerators are smaller than American ones—but also more efficient. Still, our energy use has declined since 1973, mostly due to conservation and better gas mileage.

Differences in energy use per person are reflected in the record of carbon dioxide emissions per person, as seen in the chart above. Some countries head the list because of basic inefficiencies. East Germany tops all others because its prime energy source is coal, an abundant resource, and its coal-burning plants rely on outmoded, grossly inefficient technology. Other countries in the Third World, such as China, Brazil, India, and Mexico, are simply so undeveloped and underindustrialized that their total energy expenditure is far below that of the Western industrialized nations.

GLOBAL WARMING



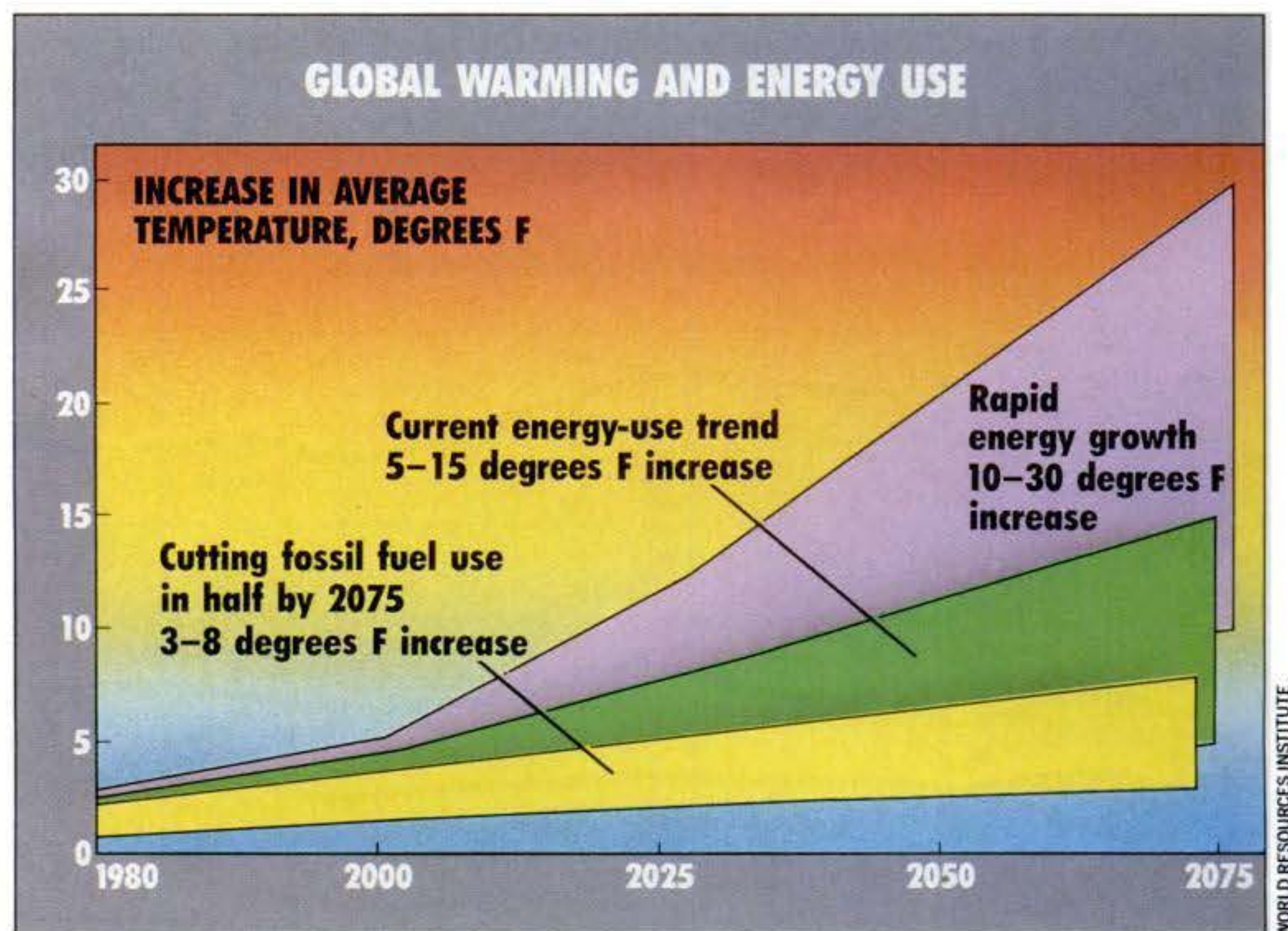
the generation and use of energy are so far-reaching, so entangled with economic, social, cultural, and even religious considerations, that the road to meaningful change is studded with tiger traps. A review of even the seemingly simple actions sketched above will reveal why.

Alternative energy options grew in attractiveness (at least in this country) in the early 1970s, not primarily because of a concern over global warming, but because they offered a chance to snip the shackles of dependence on foreign oil. Nuclear, fusion, photovoltaic, hydro, wind, tidal and ocean power, synfuels...all seemed viable alternatives to burning fossil fuels for most forms of energy use except transportation. And all except the last produce no greenhouse gases.

The trouble is that the development of most of these alternative energy sources has been captive to the gyrating prices of imported oil. When the price of oil sinks, both business and government become reluctant to invest billions of dollars in the research and plant necessary to bring these competing sources on-line in a major way.

At the beginning of the 1980s, for example, oil was \$40 a barrel and seemed likely to rise, so that a projected cost of \$60 a barrel for synthetic fuel did not look totally unaffordable. But for many reasons, including the eruption of the Iran-Iraq war, the price

[Continued on page 92]



Energy use and global warming: The rate of future climate change will depend in large part on future energy policies because they will dictate the quantity of carbon dioxide emissions. The upper chart contrasts different projections for the increase in energy generation, by source, from 1980 to 2020. A World Resources Institute (WRI) study suggests stringent conservation techniques can hold energy use almost constant. But studies by the World Energy Conference (WEC) and the International Institute of Applied Systems Analysis (IIASA) predict that even with conservation, world energy use will double by 2020, with much of the increase coming from coal and nuclear. What such different scenarios could eventually mean in global warming is shown in the chart directly above.

THE NEW 1990 AMERICAN CARS

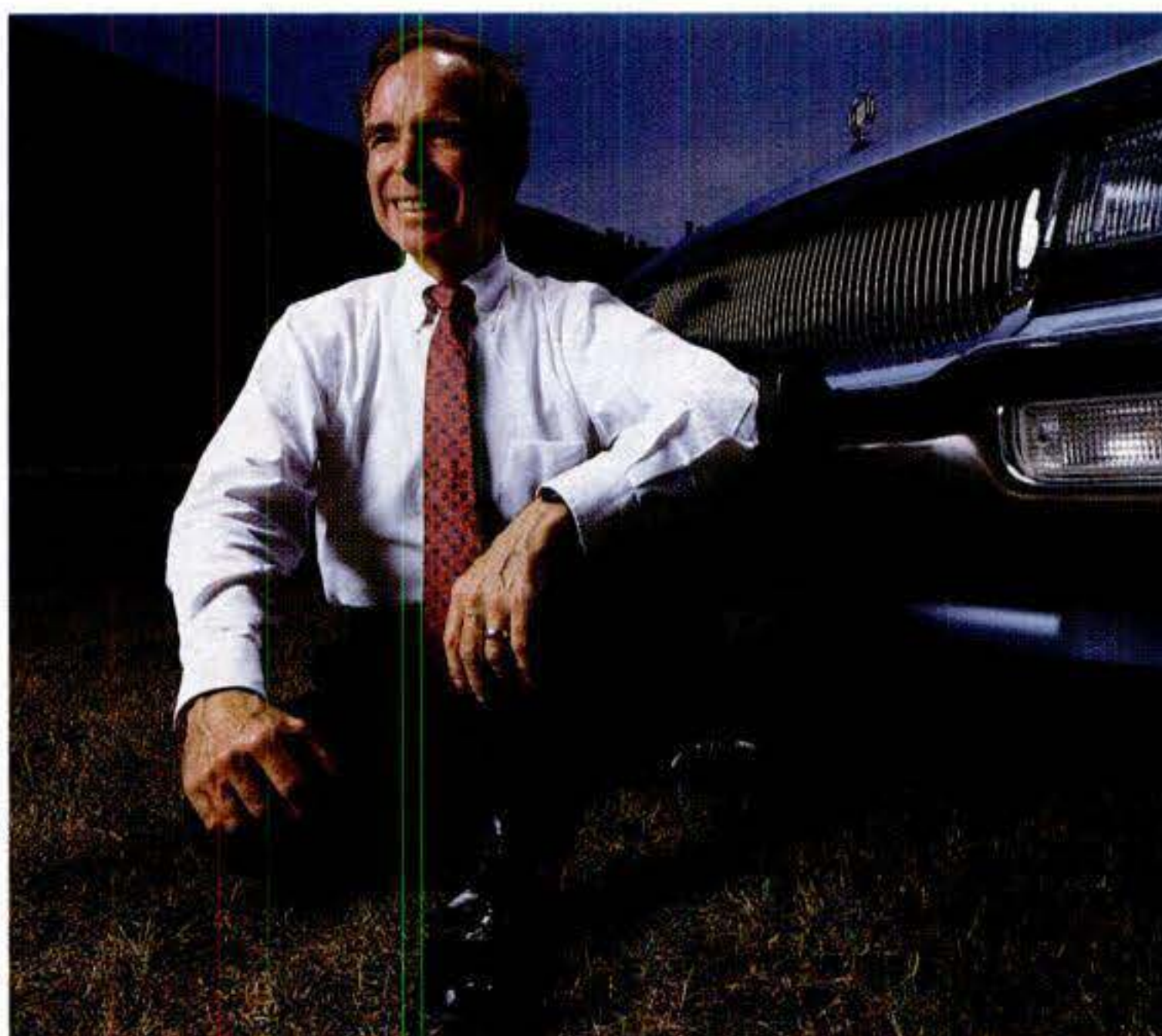
GOOD AS THE IMPORTS?

Are Detroit's cars catching up with the rest of the world in design, technical innovation, and customer satisfaction? Here's what industry leaders and watchers—both inside and outside the car companies—have to say.

By **DON SHERMAN**

At the press previews of 1990 models, Buick general manager Edward H. Mertz was unusually upbeat about his division's recent fortunes. And he had every right to be: The Buick Le Sabre had tied for second place in the latest edition of J. D. Power and Associates' annual Initial Quality Survey, and the Buick Riviera had tied for tenth overall. According to this respected survey of owner-reported problems during the first three months of ownership, Buick scored seventh out of 37 domestic and import brands; Buick was the top American marque on the list.

Mertz's enthusiasm didn't stop with the Power Survey results. He went on to compare the Le Sabre in a favorable light with the highly regarded Acura Legend. "In terms of fuel economy, Le Sabre's numbers are nineteen and twenty-eight miles per gallon in EPA city and highway tests respectively." In comparison, the Acura Legend with an automatic transmission delivers 18 and 22 mpg in EPA tests. "In highway range," Mertz adds, "the Le Sabre runs 504 miles per tank,



“Buick is now more than competitive”

—Edward H. Mertz, general manager
Buick Motor Division

compared with 296 miles for the Legend. The Acura does beat us in zero-to-sixty-mile-per-hour acceleration, but only by two-tenths of a second." Mertz was also proud of his car's base price: \$15,800, as compared with the Legend's \$23,000.

It is the goal of every car maker to be world class in quality, engineering, design, and customer satisfaction. By confronting the revered Acura Legend and beating it in several objective comparisons, Mertz claims: "Buick is now more than competitive. I believe we're world class."

This optimism has now spread to all corners of the domestic auto industry. The opinion that America really is catching up with the world's premier auto makers is slowly gaining momentum. To achieve world class status, American car makers must:

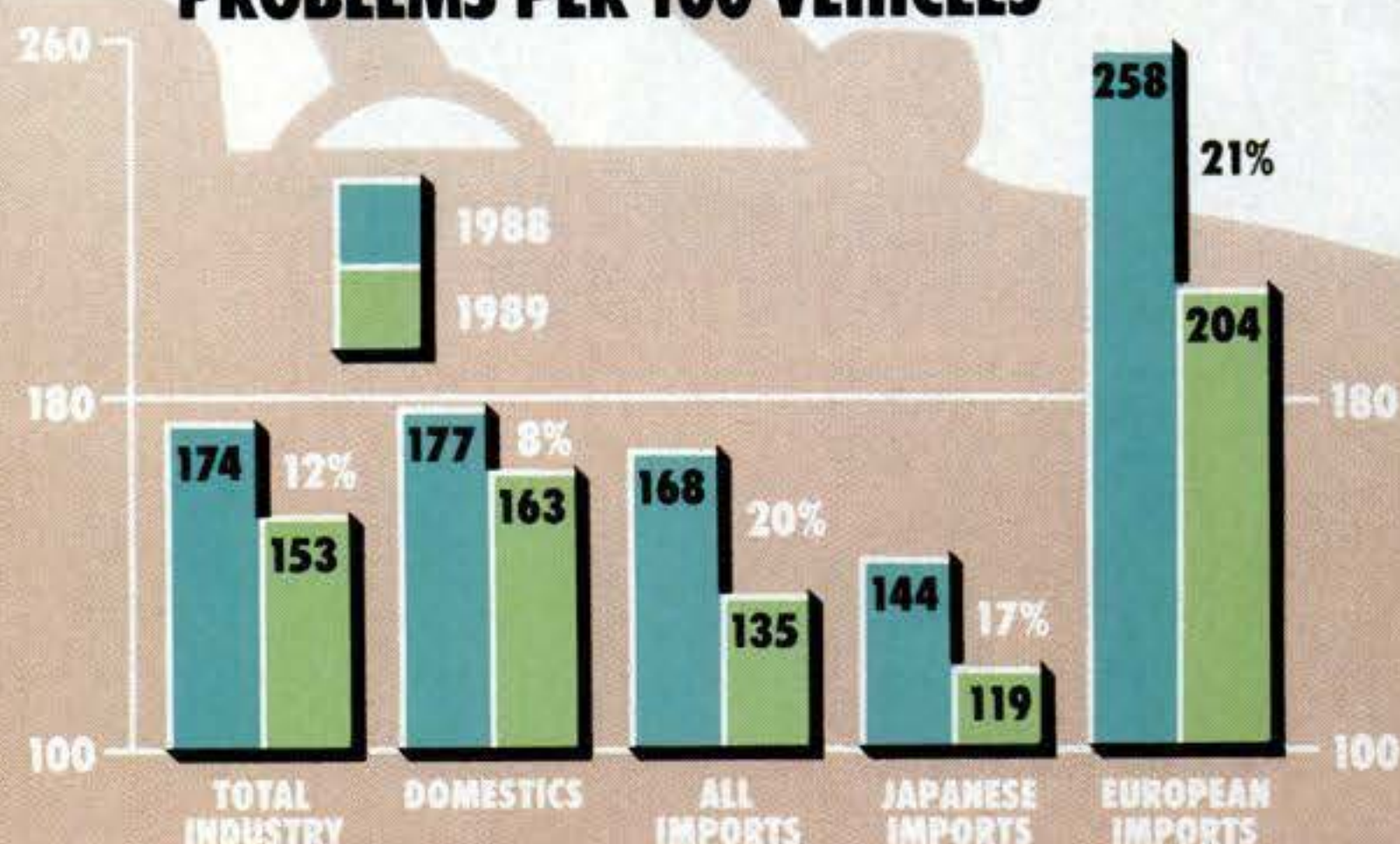
- Satisfy the customer with excellent performance, reliability, and dealer service.
- Offer outstanding value.
- Build automobiles with innovative and relevant technology.

How well is Detroit responding to these challenges? After studying cus-

Continued

THE TOP FIVE CAR MODELS

TRACKING THE QUALITY OF CARS PROBLEMS PER 100 VEHICLES



*Shows quality improvement in percentage terms

Comparing quality, the Japanese build on their lead. European car makers make impressive strides in quality, but still fall short. The domestic industry is improving, but slower than the import sector, especially the Japanese.



1. NISSAN MAXIMA



2. BUICK LE SABRE



2. TOYOTA COROLLA



4. FORD CROWN VICTORIA



5. MERCEDES-BENZ S-CLASS

Based on the J. D. Power and Associates' Initial Quality Survey of owner-reported problems, the highest quality car sold in the United States is the Nissan Maxima. In second place, the Buick Le Sabre tied with the Toyota Corolla, followed by the Ford Crown Victoria in fourth place, and the Mercedes-Benz S-Class sedan in fifth.

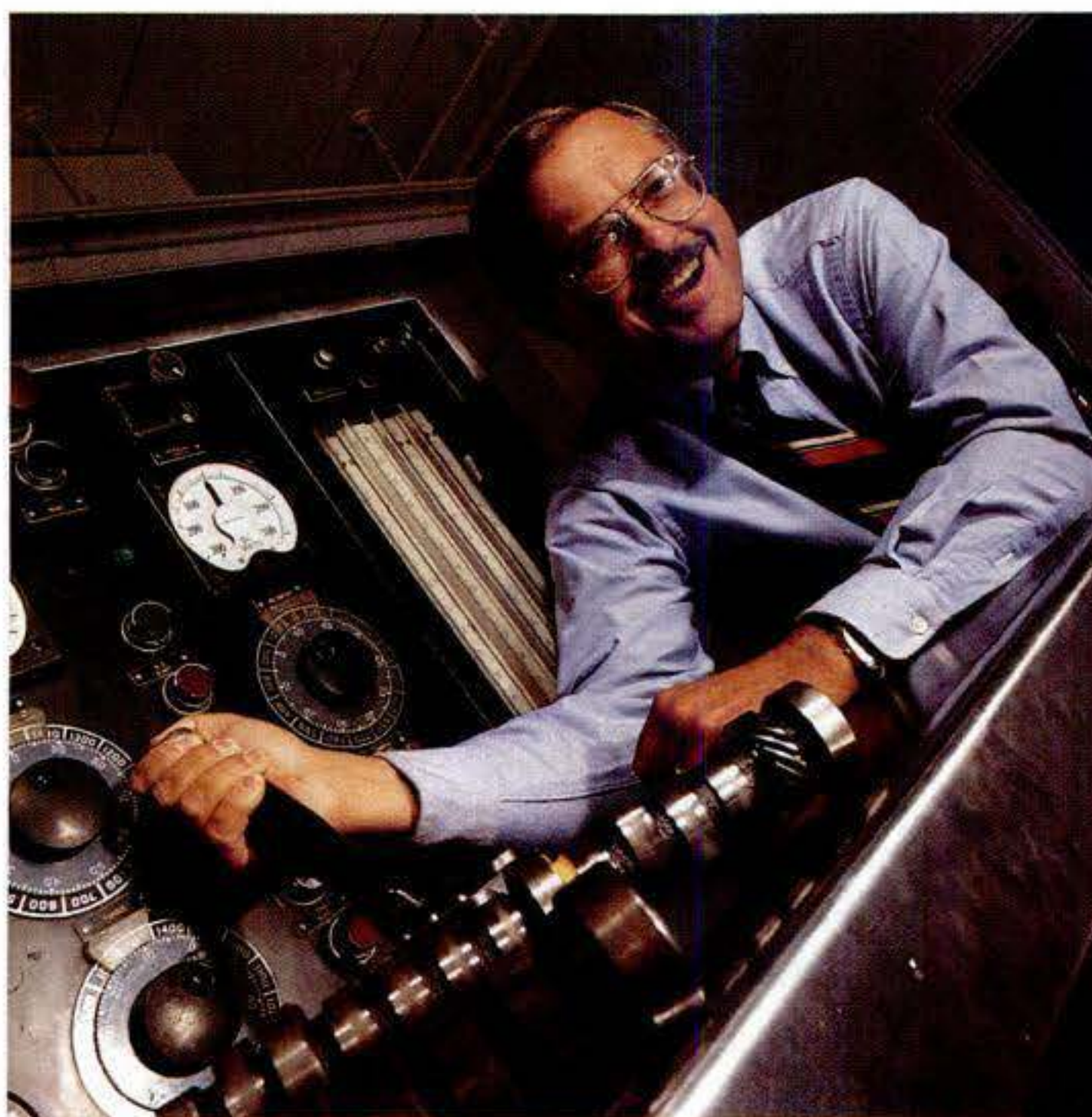
tomer surveys and interviewing industry leaders and observers, I found that while Motor City fortunes are indeed on the rise, there are major hurdles ahead.

Quality is a priority

Comparing 1988 and 1989 domestic models, the Power Initial Quality Survey shows that the number of customer-reported quality problems per 100 domestic vehicles dropped from 177 to 163, an eight percent gain in customer satisfaction. Collectively, the European manufacturers showed an even more impressive 21 percent improvement: 204 problems per 100 cars in 1989 as opposed to 258 problems in 1988. As the world shifts into high gear on quality, the Japanese are moving ahead even faster, with a Power quality rating of 119 defects per 100 cars, a 17 percent gain over 1988. Clearly the American car makers are achieving better quality, but it is against the backdrop of an increasingly competitive world where quality design and construction separate the winners from the losers.

Each car maker also monitors warranty claim data as a gauge of customer satisfaction. Says Chrysler president Robert Lutz: "We now have two car lines where the C's per hundred cars [the number of concerns, or reimbursable warranty claims within the first year of ownership] are below 200. American cars used to be in the 600 range. On average, the Big Three are now down in the mid-200s in customer concerns. Up until three years ago, the sub-200 level was exclusive Japanese territory. We're making the fastest progress in history, and we're finding that some of the Japanese brands are actually deteriorating in this area."

It is clear that the Japanese auto makers build the highest quality products, but have a much harder time satisfying their customers when something does break. According to the J. D. Power Customer Satisfaction Index, which tracks the resolution of problems at the dealer level, all of the Japanese brands scored below the industry average of resolving 53 percent of problems. Nine of the 12 domestic makes listed scored above average at fixing defects when they occurred, with Chrysler resolving 61 percent of owners' problems—the best record for 1989. Granted, domestic manufacturers had more problems to start



“The challenge is to sell truly relevant high technology—not talking dashboards”

—David Cole, University of Michigan

with, but they seem better able to fix them when they do occur.

Lutz, whose company is the perennial domestic leader in the customer satisfaction survey, thinks this type of data is a godsend: "You can't terminate a dealership for not selling cars, but manufacturers can cancel a dealer's franchise agreement for consistently sub-par—below national average—CSI ratings."

Experts agree that great strides have been made in manufacturing quality during the 1980s, and some suggest that the domestic auto industry is quickly approaching the point where quality is no longer a critical issue. According to David Cole, director of the Office for the Study of Automotive Transportation at the University of Michigan: "If one brand has a quality rating of one defect per car and another has a rate of 0.8 defect per car, the difference is insignificant.

Quality then ceases to be a discriminating factor in the buyer's purchase decision."

Lutz agrees: "I think within five years, quality will not be a differentiator."

When asked where he thinks Japan still holds the lead, Cole doesn't hesitate to answer: "The Japanese set the benchmark in all details related to execution of the product." He points to the efficiency of their engineering efforts as setting them apart from the world. "They can design, develop, and produce very complex products at very high quality levels quicker and less expensively than anyone. Nevertheless, the American manufacturers are improving. I don't think the gap in

ability to execute engineering that exists between America and the Japanese is lengthening."

The recent Massachusetts Institute of Technology Commission on Industrial Productivity, composed of economists, engineers, and scientists, reports that on average American car makers take five years to develop a car fully, compared with 3.5 years for their Japanese counterparts. The major reason, the commission found, is that the domestic manufacturers spend twice the engineering resources to produce a new model.

Structure and bureaucracy play key roles in which auto maker can engineer products the quickest and the best. At this summer's new-car introductions, I noticed actions aimed at cutting layers of bureaucracy and streamlining the process.

At Chrysler, two relatively new leaders—president Robert Lutz and vice president of vehicle engineering François Castaing—have reorganized this automobile manufacturer's engineering departments. The old system was built around vehicle components: engines, transmissions, bodies, and so on. The new system is based on automotive platforms and more closely reflects the finished products. The new groups include: Jeep and Truck; current automobile platforms; the new generation LH/LX sedans that are expected in the next three years; small engineering projects, such as the Viper sports car; and the Liberty advanced-technology group. The auto manufacturer's goal is to allow engineers working on different aspects of the same project to communicate easily and resolve conflicts, without ex-

Continued

pending effort wading through innumerable layers of bureaucracy.

Computerized design

Another innovation at Chrysler is a computer-aided styling system that permits designers to sketch automobiles in uncanny detail on video screens—right down to realistic surface highlights and reflections. The complex process of refining a new design can now be done using computer representations, with no need for time-consuming clay models until the creative phase is essentially complete. Trevor Creed, Chrysler's director of interior and truck design told me this one new tool—so far a Chrysler exclusive—will trim a full year off the four it now takes to prepare a Chrysler product for market. This advance in computer-aided design could bring Chrysler close to the Japanese standard of a three-year design cycle from concept to product.

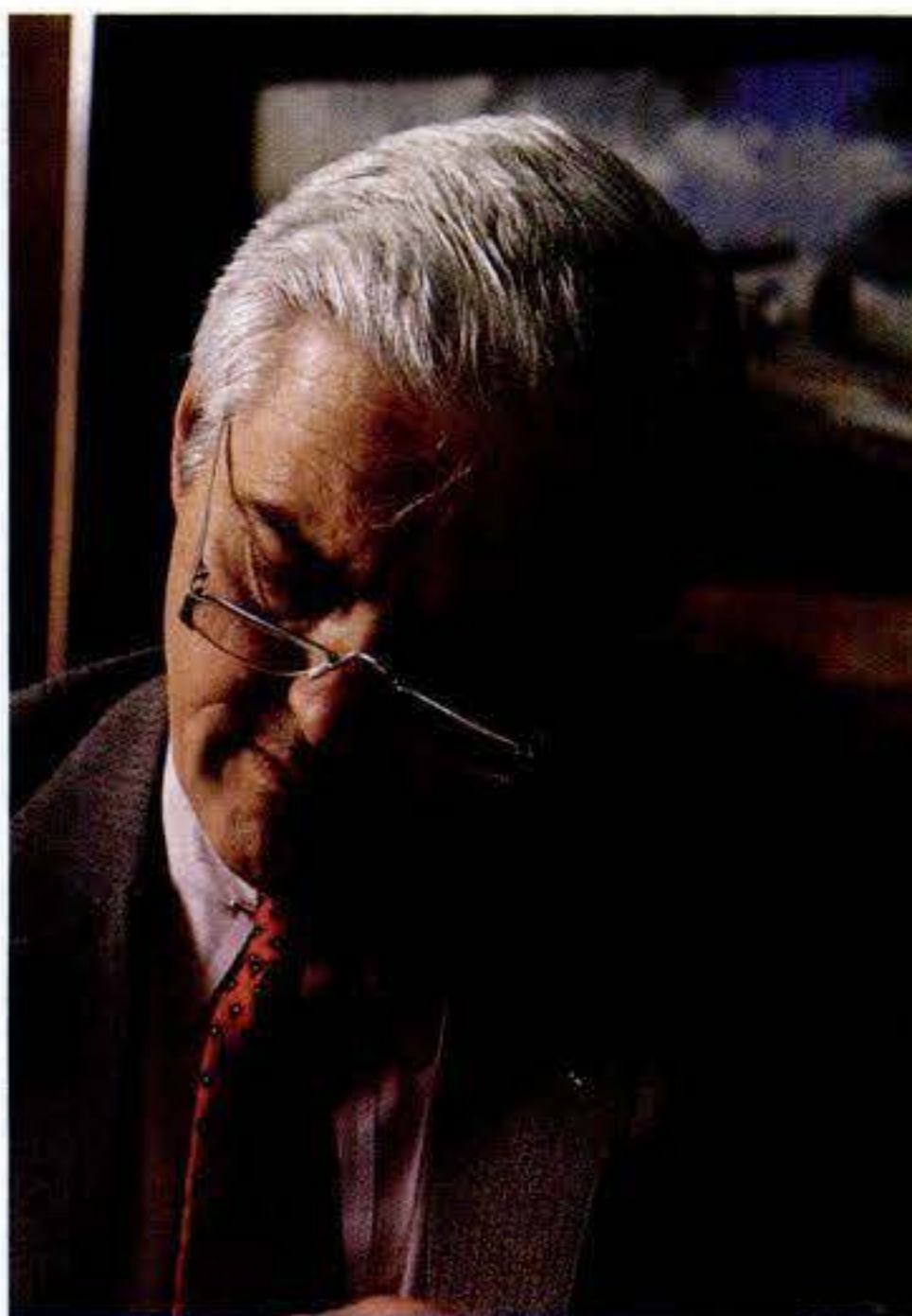
At the 1990 Chrysler press preview, Lutz told me of another area where America is catching up: "We're closing the gap fastest in design. In fact, I don't think the United States ever lost its lead in this area. We may have pursued the wrong direction for a while, but American designers and aesthetics have always been at the forefront of the world."

Many look to Ford as the American standard bearer in worldwide auto design. With an impressive streak of engineering successes, including the Taurus/Sable line and the supercharged Thunderbird Super Coupe/Cougar XR-7, Ford chairman Donald Petersen thinks that his company has caught the pack of Japanese car makers. But he feels Ford is still chasing two of Japan's best: Toyota for its superior product quality and Honda for the speed at which it can introduce technical innovation.

The technology gap

The most difficult challenge facing Detroit today may be in embracing the latest technology. The Japanese auto makers have a clear lead in incorporating today's technology into their products, and they show no signs of slowing down. Meanwhile, America seems to be running the technological race in leg irons. Says Toyota executive vice president Robert McCurry, a former Chrysler executive: "I don't think the domestics are any closer in technology today than they were five years ago."

A case in point is variable valve technology. Honda, Nissan, and Mercedes-Benz now have cars on sale that



“W

**e're
making the fastest progress
in our history”**

**—Robert Lutz, vice president for
vehicle engineering, Chrysler Corp.**

adjust the intake valve timing with respect to engine speed. This technical advance reduces the compromises between high output and smooth operation of four-valve-per-cylinder engines. No domestic auto maker has yet announced plans to use such an advanced valve train.

It's not that American engineers can't figure out new technology, like adjustable valve timing, multivalve combustion chambers, or all-wheel drive lines. J. T. Battenberg III, vice president and group executive of GM's Buick-Oldsmobile-Cadillac group, insists that "technology is not the problem. We have plenty of high-tech. The difficulty is getting it into the cars without driving prices out of reach."

Decisions also are based on what Detroit thinks its customers want. An interesting example is the new-for-1990 Lincoln Town Car (see "Big Is Back," this issue). Clearly price is not a major concern here. With a base price of approximately \$28,000, it is one of Ford's most expensive and successful products. The 1990 edition was engineered with great deliberation.

Except for the addition of rear air springs, anti-lock brakes, and minor steering improvements, the Town Car's 11-year-old chassis continues its second decade of production virtually unchanged. There is no new ultra-sophisticated engine, electronically controlled transmission, or independent rear suspension in the new Town Car because Ford analysts felt the customers wouldn't appreciate those items. Instead, the interior and exterior were modernized without tampering with the car's traditional styling. Ford engineers also took great pains to improve the ease of building the Town Car. The goal: build cars at higher quality levels than were the norm during the 1970s when the Town Car was last redesigned.

If the new Lincoln Town Car is a success in the showrooms this fall, it will not be due to advanced technology. Rather, it will be because of roominess, a soft ride, and an aura of prestige that appeals to the Town Car buyers. Successful low-tech models like the Town Car discourage American manufacturers from taking the plunge into the deep waters of advanced technology.

World leaders

Lutz, Cole, and other automotive industry watchers insist that America leads the world in certain engineering fields, particularly engine-control electronics. Detroit has made major progress in the application of advanced fuel injection and in designing cars with improved aerodynamics. And it was American industry that invented the bulk of emissions control equipment that the European auto makers are just now putting into widespread use. Another area in which the American car makers currently hold a lead is in the installation of air bags, with Chrysler leading the pack by promising to have driver-side air bags on 16 car lines in 1990, amounting to approximately one million cars.

As far as drive-train components go, however, America lags behind the world's best. Chrysler is the only American car maker with an electronically controlled automatic transmission, now a mainstay on German and Japanese models. And while Toyota and Mercedes-Benz now offer five-speed automatic transmissions, General Motors still relies heavily on three-speed automatic gearboxes. In fact, it's rare that any new GM product is born with a genuinely modern power train. A perfect example is the APV minivan [Cover story, June]. Under the van's futuristic-looking plastic skin lies an old-tech 3.1-liter V6

Fuel economy? The energy crisis is a faint memory. Bigger cars, engines, and the transmissions to back them up highlight the 1990 model year. Sounds familiar—but this time innovations in computer-based braking and traction control are used to maximize ride, performance, and, yes, even fuel economy.

BIG

IS BACK.

WITH A HIGH-TECH ADVANTAGE

By DAN McCOSH and BRIAN NADEL



mated with a rustic three-speed automatic transmission.

Cole points out the distinction between high technology and high precision. "High tech is four-valve combustion chambers and all-wheel drive. High precision is making the cylinder bores perfectly round and straight every time," Cole says. "America is finally achieving high precision in engine manufacturing, something the Japanese had to accomplish a long time ago to take the next step with their high-revving, high-specific-output small-displacement engines."

Relevant technology

"Now," says Cole, "the challenge to both America and Japan is to sell truly relevant high technology—not talking dashboards. Everybody wants four-wheel drive if it's free; when it costs \$2,000 there are fewer takers. Multivalve combustion chambers are also difficult to sell to value-conscious consumers because not everyone understands the benefits."

Virtually every Toyota sent to America—from the compact Corolla to the just-introduced Lexus LS 400 luxury sedan—is powered by a sophisticated engine with a four-valve combustion chamber. The Big Three sell a few four-valve-per-cylinder engines as well. All but two—GM's Quad 4 and the Corvette LT5 V8—are made elsewhere. Recently General Motors invested heavily to modernize two of its pushrod V6 engines dubbed 3300 and 3800, denoting their displacement in cubic centimeters. Updates for these engines include:

- State-of-the-art fuel delivery systems.
- Cylinder bores re-centered with respect to crankshaft journals to reduce drive-line vibration and harshness.
- A balance shaft to smooth operation in the larger of the two engines.
- Advanced machining and statistical quality control in the manufacture of the engines.

The result was two "new" engines that are certainly high precision, but not genuinely high tech. That includes the tuned-port-injection version of the 3800 V6 that GM's Buick division will introduce on the Regal this spring. As long as GM V6s use pushrods to open valves and eschew overhead-camshaft valve actuation, they'll have some difficulty winning the respect they deserve.

Simple, durable technology

It is GM's contention that the low-tech approach is beneficial to the customer because the extra expense of an



“Technology is not the problem. The difficulty is getting it into the cars without driving prices out of reach”

—J. T. Battenberg III, vice president
Buick-Oldsmobile-Cadillac Group

exotic valve train is avoided, yielding a simpler and more reliable power plant. In fact, Ed Mertz's pride and joy, the Buick Le Sabre, which scored so well on the J. D. Power survey, uses the 3800 V6 engine exclusively. In the two years it's been on the market, the Le Sabre's warranty claims have been reduced by 70 percent, and they are now approximately one-tenth what they were as recently as the 1986 model year.

Instead of the small-displacement high-revving overhead-cam engines fa-

vored by the Japanese, Detroit generally favors larger, slower-turning engines to power its typically heavier cars. This approach has some important engineering advantages that go beyond lower manufacturing costs and the inherent durability of a simpler design: better low-end torque, quieter running on the highway, and, in some instances, superior fuel economy. So the issue is not a simple desire on Detroit's part to postpone the design expense and new tooling necessary to produce high-tech engines: With a large base of traditional customers who rank value highly in their purchase decisions, it would be foolhardy to rush the application of advanced technology just so Detroit could mimic the Japanese.

Nevertheless, Detroit has been so hesitant to turn its back on traditional value-conscious customers that the Japanese and Europeans have easily attracted the younger, wealthier buyers eager for fun-to-drive advanced-technology automobiles. A quarter of a century ago, the name Honda stood for 50-cc motorcycles and Cadillac was the standard of automotive luxury. Now the Honda name is uttered with reverence bordering on a religious experience, and Cadillac is desperate for recognition.

Explaining the recent flourish of Japanese-made high-tech sports cars—from the powerhouse Nissan 300ZX to the soon-to-be-introduced Acura NSX—Steve Wall, corporate product development manager at Nissan, says, "The Japanese want supremacy. They are intent on achieving success. But success to U.S. companies is based on profits, while the Japanese want reputation."

There is an undeniable link between technology and image that is far stronger than the tie between technology and performance. Mertz's Le Sabre and the Acura Legend may be neck and neck in 0-to-60-mph races, but there's a yawning gap in image between the two. To its everlasting credit, Buick has proven that achieving world class quality is well within its capability. The next logical step is obvious. Buick—and every U.S. car maker genuinely interested in winning world class auto making status—must plow a greater share of its profits back into developing and refining its cars. It must put greater emphasis on engineering and build a new generation of automobiles that is the envy of the world. Investing for the future in truly relevant technology will simultaneously uplift both the performance and prestige of American automobiles.

PS

As recently as a decade ago the imminent death of the large American luxury sedan seemed as certain as the gas lines that extended around the block. Gas price hikes and government-mandated pollution reduction and fuel economy requirements signaled the end for these behemoths.

But Americans got used to higher gas prices and at the same time rejected small luxury cars. For 1990 Detroit returns to the once sacred theme of "bigger is better." This time around power and size are accompanied by sophisticated electronics and engineering as never before. While the 1990 model news may seem somewhat retrograde, some timely technical innovations are beginning to appear. A prime case in point is integration of various electronic systems for total motion control. More on that later.

The 1990 luxury cars—including the Lincoln Town Car and Chrysler Imperial—are better built, easily out-handle their forebears, and do it within tight EPA emissions limits and with double-digit fuel economy. At Ford, a new conservatively styled body for the Lincoln Town Car ensures the survival of that V8-powered, rear-drive, full-frame classic. Ford sticks with a successful, if dated, recipe with such ingredients as a rigid rear axle and the five-liter V8 engine of its predecessor, but adds in anti-lock brakes, rear air suspension, speed-sensitive power steering, and aircraft style doors with flush windows. The result is a conventional, quiet, no-fuss luxury car that transports six passengers and their luggage. The styling follows Ford's most recent design successes: the Taurus and Thunderbird. The Town Car's

coefficient of drag was trimmed from 0.46 to 0.36, with vastly reduced wind noise as the most striking outcome.

I recently had a chance to test the Town Car's electronically controlled rear air suspension. The ride is dominated by a heavy floaty feeling that is undisturbed by minor road bumps, yet has a reasonably solid feel in the corners. The rear axle is suspended on air springs reminiscent of those on a Greyhound bus. These coffee-can-shaped devices are automatically pumped up to compensate for load variation, so it doesn't matter if your Aunt Bertha or your briefcase is sitting on the back seat.

For 1990 Chrysler has revived the Imperial nameplate. It's the latest, and hopefully the last, K-car derivation. The sedan is a mere 68.9 inches wide and can comfortably accommodate only two across in the back seat. A full air suspension, which Chrysler engineers told me will reduce the compromises of a coil spring suspension, is offered. And by using Chrysler's 3.3-liter V6 and four-speed automatic transmission, the gas-guzzler penalty is avoided. The Imperial is planned for a late fall introduction.

The rear-drive Cadillac Brougham gets a revamped 5.7-liter V8 engine option with throttle-body fuel injection. The engine is rated at 175 horsepower, with an abundant 400 pound-feet of torque that is available at a sedate 2,000 rpm. However this comes at the expense of fuel economy rating: 14 mpg in the EPA city test and 24 mpg on the highway, and an \$850 gas-guzzler tax.

If you parked the Caddy and Town Car next to each other, you'd see that barely an inch separates them in

length and height, although the Brougham is slightly narrower. Side by side, the Town Car's rounded, flowing lines look more up to date to my eye than the Brougham's sharp, angular styling.

Docking fees would seem more appropriate than parking tickets for the new cars that dominate the 1990 introductions. But there are some sportier derivations as well. However, raw power has been tempered with electronics as never before.

At the Cadillac press introduction, engineers dumped a gallon of dish detergent onto an already wet road. Were they trying to clean it? Actually, the engineers were creating a surface 10 times slipperier than ice to test the 1990 Allanté's traction-control system. I slammed open the throttle, anticipating spinning wheels and wild darting as the front-wheel-drive car tried to grab for traction. Instead, the drive wheels accelerated only to where they began to slip, then slowed enough to grip the pavement—despite my foot pushing the accelerator pedal to the floor.

The traction-control system integrates sophisticated computerized motion-detection technology with devices designed to control the drive train. These systems rely on a disc rimmed with evenly spaced slots that generates a voltage spike when passed by a stationary coil. Locked to a rotating shaft, this seemingly simple device converts the wheel's mechanical rotation into a series of digital pulses from which a microprocessor can deduce speed.

The control computer looks for a wheel stepping out of sequence from the others—the first indication that

Continued



Designers of the Lincoln Town Car were able to retain the car's traditional upright styling, while giving it a more modern look and improving airflow over the body: coefficient of drag was reduced from 0.46 to 0.36.

DETROIT **PREVIEW**

a wheel is spinning. When the Bosch-designed system detects a 10 percent speed difference between the wheels, it springs into action, pulsing the runaway wheel's brake, slowing it enough to regain grip. Keep the throttle open for more than three seconds, and a secondary logic circuit begins cutting off fuel to the engine's injectors one at a time. This, in turn, drops the engine's output, making wheelspin all but impossible.

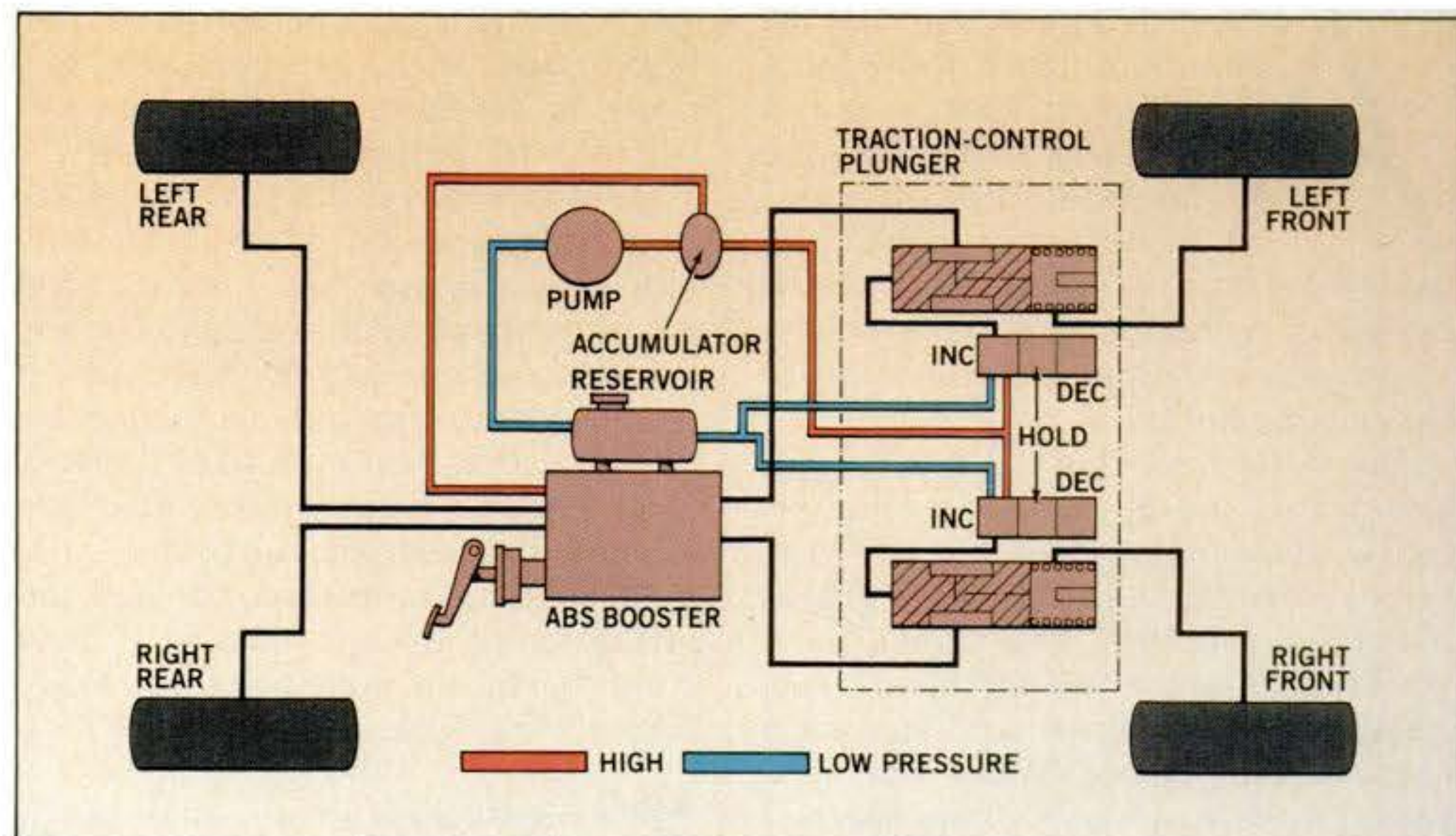
The Allanté's traction-control system demonstrated to me the potential for one computerized system to "build" on another, creating a sort of computerized synergy. The race is on to integrate all electronically based motion-control systems completely: four-wheel drive, traction control, and anti-lock brakes. The goal is for all the motion-control devices to interact smoothly.

The first act in the elaboration of the motion-control play appears to be the 1990 Corvette, which uses a lateral accelerometer to balance the brakes fore and aft in hard cornering.

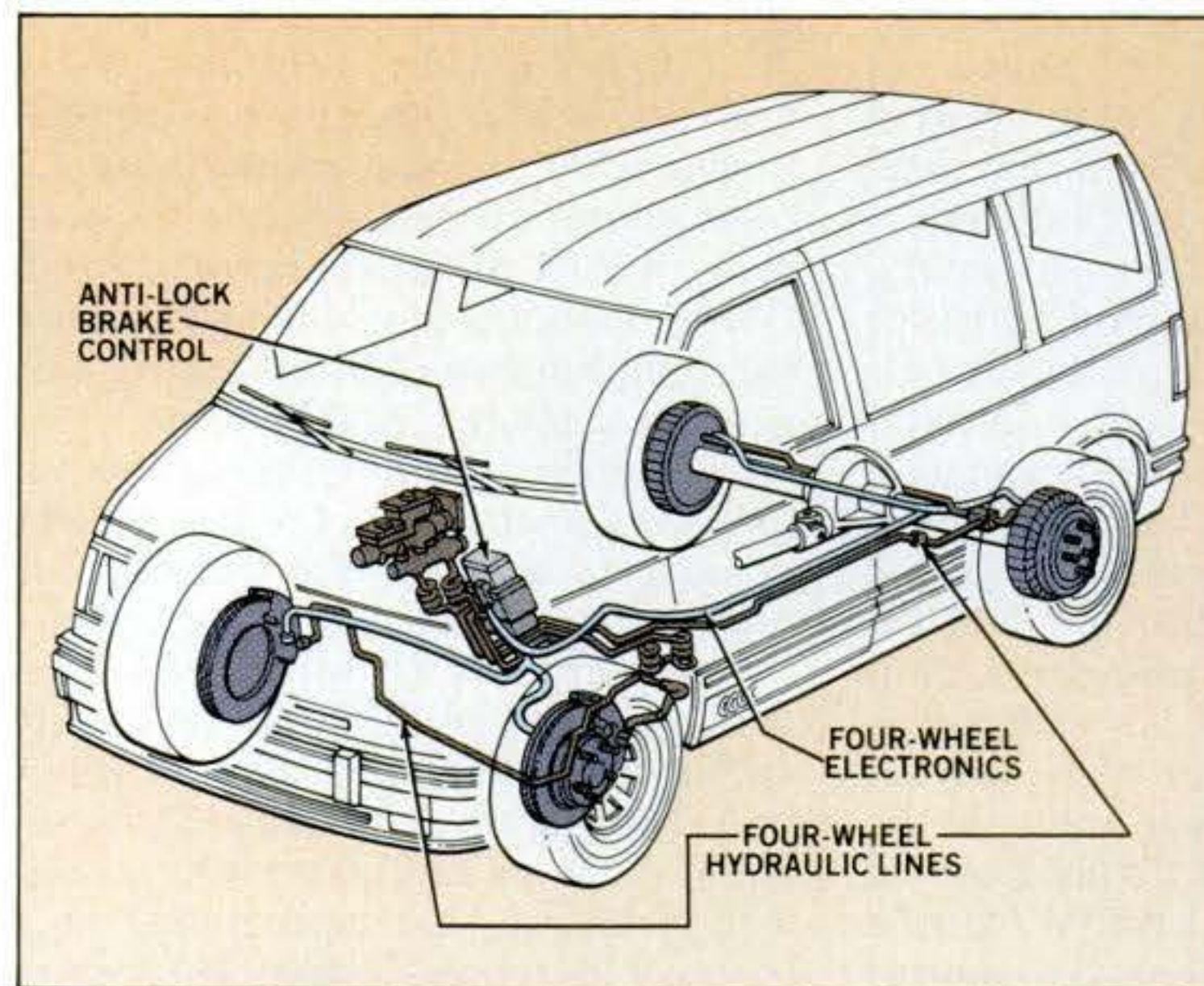
When I tested the third generation Bosch ABS system on the 380-hp Corvette ZR-1, I had the strange sensation of tempting fate. I was coming down the rain-slicked Watkins Glen, N.Y., track at 130 mph and threw caution to the wind by slamming on the brake pedal. I then felt the anti-lock brakes ratchet and pulse as the brake pads grabbed and released in a controlled and powerful manner to bring the car safely to a stop. The matchbook size lateral accelerometer senses when the Corvette is about to slide, and in an instant signals the computer to adjust the balance of braking force between the front and rear brakes to stabilize the stop.

At the other end of the economic practicality scale, Ford unveiled a low-cost electronically controlled four-wheel-drive system for its Aerostar minivan. The Ford four-wheel-drive system couples the front and rear axles through a planetary gear that allows each axle to run at its own speed—essential to on-road full-time operation.

Ford's new electronic four-wheel-drive system employs a wheel-speed sensor at each side of the planetary gear, where power is split one-third front, two-thirds rear under normal driving conditions. When the sensors detect a speed difference between the front and rear wheels—a sign one of the minivan's wheels has lost traction—the transfer case planetary gear is



ILLUSTRATIONS BY
RUSSELL VON SAUERS



automatically locked with an electromagnetic clutch, and power flows to the front and rear axles equally. Three seconds later the transfer case will unlock briefly to reevaluate the situation.

The Ford Aerostar system works well over a variety of situations, although the drive train made a noticeable lurch on starting and later when one wheel dropped onto a section of gravel.

An interesting contrast is the Chevrolet Astro four-wheel-drive minivan, which uses a viscous coupling across the planetary gear rather than elaborate sensors and electronics. This all-mechanical system bridges the gap between the front and rear wheels with a series of parallel plates alternatively connected to the front and rear wheels, and riding in a special silicone fluid (see drawing). If all wheels have good traction, the plates rotate at the same speed, and the viscous coupling unit has no effect. But if one wheel loses grip with the road, the stiff liquid partially locks the front and rear wheels together.

Chevrolet claims the major benefit is simplicity, and presumably reliabil-

When front wheels begin to lose grip, wheel sensors on the Cadillac Allanté's traction control system (top) send a signal to the computer to activate the anti-lock brakes via a specialized plunger assembly. The brake fluid enters traction control plunger to produce short pulses of brake pressure to slow the spinning wheel. If wheelspin continues, the engine is shut down sequentially by cylinder. Chevrolet Astro (above) is the first minivan with four-wheel anti-lock brakes. Sensors at all four wheels determine wheel speed, and the brakes are individually pulsed if the computer detects any significant speed difference between wheels.

ity. The operation of the all-wheel drive train on the Astro is so unobtrusive as to be invisible to the driver. Traction is sure-footed and smooth, in contrast with the Aerostar, where you can feel the transfer case locking if it engages with the wheels spinning.

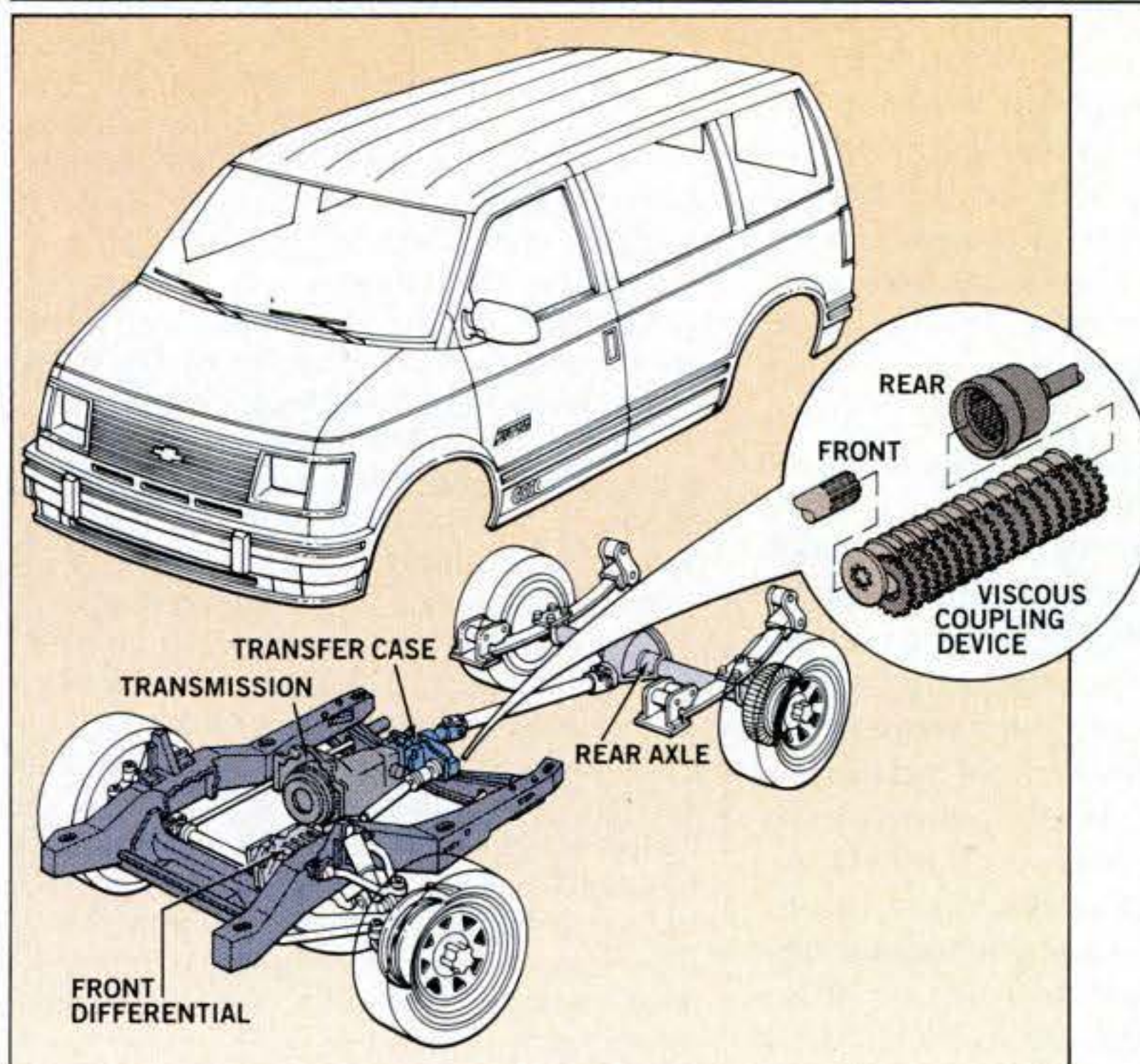
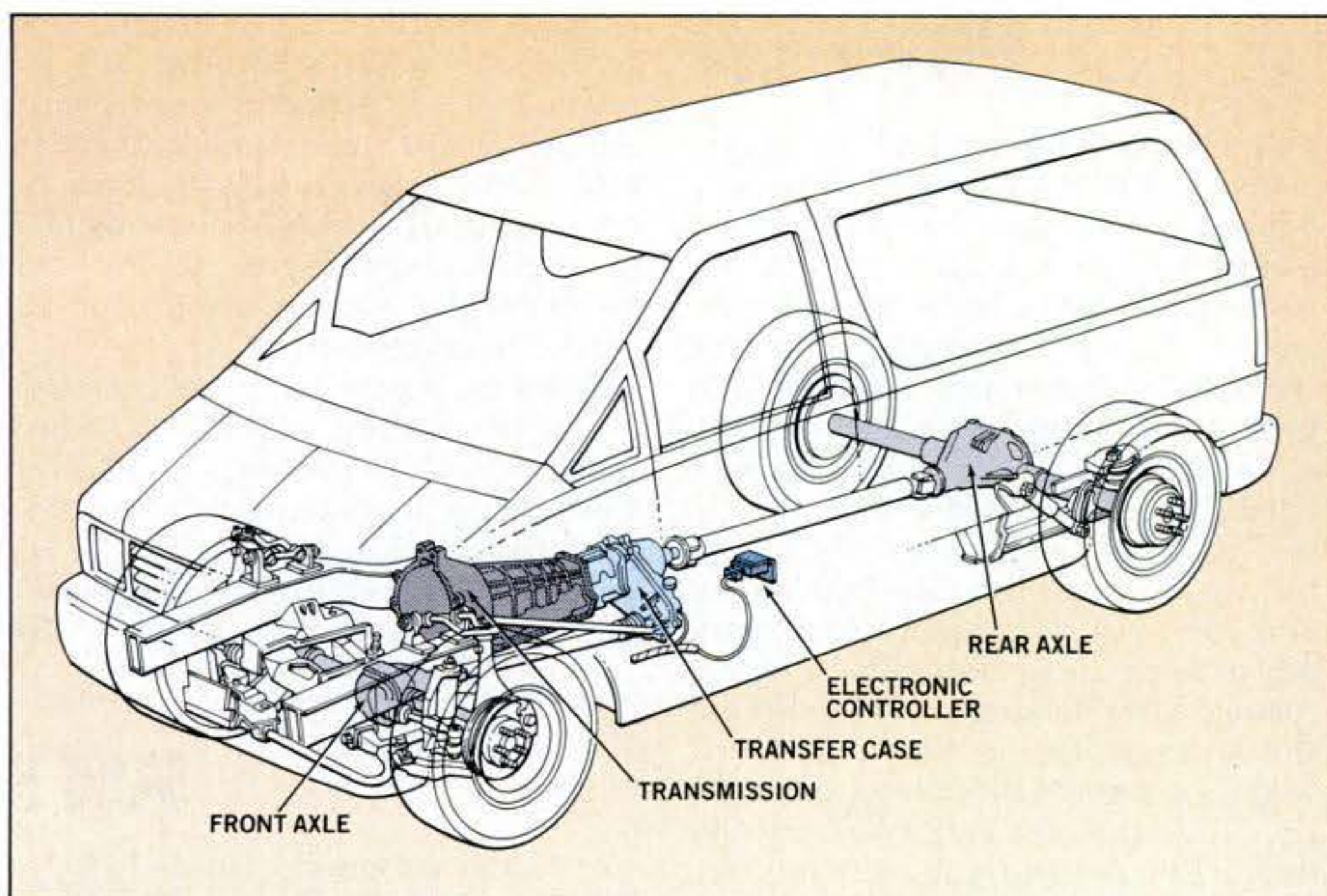
The Astro also is the first minivan

to use the new Kelsey-Hayes four-wheel anti-lock brakes. This system is similar to ABS in cars by using wheel-speed sensors at each wheel, rather than a single unit on the rear axle. In this way, each brake can be individually pulsed for better braking performance (see drawing).

Minivans from Chrysler still lack an all-wheel-drive option or even anti-lock brakes, but these models, as well as the company's smaller front-drive models, will get a new five-speed manual transmission. The vague feeling of Chrysler manual gearboxes, which made the shifter feel like a butter churn, has long been a sore point. By using a three-plane geometry setup, the transmission has a more positive feel, and vastly smoother operation. Engineers told me that by increasing the bearing surfaces and generally bolstering the design, they were able to reduce internal friction and shift effort. It is a step forward for Chrysler, which is trying to cultivate a sportier image these days.

Chevrolet's Geo line presents two of this year's most exciting cars. First, there is the all-new two-seat Storm, designed and built by General Motors' Japanese affiliate Isuzu. Powered by an optional 1.6-liter dual-overhead-cam 16-valve engine, the 125-hp Storm is a worthy competitor to Honda's CRX coupe. With a 51.1-inch height, you can hold your hand out and easily pat the Storm on the roof. In fact, the car is so cute that you are inclined to do something like this at first acquaintance. On the track, the Storm trades cute for aggressive, although it is not an overwhelming car. The sleeper in the Geo lineup is likely to be a sport edition of the Geo Prizm sedan, a product of the joint venture between GM and Toyota. The Prizm GSi has a 1.6-liter 16-valve 130-hp engine and a specially tuned suspension that is enjoyable to drive both at the track and on public roads. The Prizm GSi is extraordinarily smooth and powerful, but is a late entry in an already crowded class of sport sedans.

Most of the remaining performance cars introduced this year are surrogates of previous models with some kind of hormone injection of a new power plant. Oldsmobile and Chevrolet use a more potent 180-hp version of the Quad 4 2.3-liter 16-valve four-cylinder engine to create a "new" Olds 442 Calais and Beretta GTZ, respectively, while Pontiac is using the Grand Am as a showcase for this little gem of an engine. Engineers made the 30-hp upgrade by raising the compression ratio to 10:1, using a more aggressive cam profile, and enlarging the valves. On the road, though, the



most noticeable feature is the result of a noise-reduction program that quiets this high-output engine.

The engine of choice for 1990, however, is the V6, which is beginning to squeeze out turbocharged four-cylinder engine options in sporty cars. Ford is adding a three-liter V6 option to the Mazda-built Probe and Chrysler now will make the Mitsubishi-built three-liter V6 available in the Daytona and Le Baron coupes. Chrysler also unveiled the first volume production application of a variable-nozzle turbocharger as an option on both the Daytona and the diminutive Shadow ["Turbo To Go," Aug]. After driving the VNT-equipped car, I felt the most impressive change was the addition of a balance-shaft system that effectively soaks up much of the engine's roughness.

Two approaches to all-wheel drive. Top drawing shows the Ford Aerostar minivan with its electronically controlled locking planetary gear that divides engine power between front- and rear-drive wheels. By contrast, the Chevrolet Astro (above) uses an all-mechanical approach. Power is divided between the front and rear wheels by a viscous coupling (see detail) just behind the transmission.

Chrysler now uses driver-side air bags to satisfy 1990 government passive restraint requirements on 16 of its car lines, a total of one million autos. This has meant a full redesign of the automobile manufacturer's steering wheels that for the first time in-

Continued

DETROIT PREVIEW

corporate cruise-control switches.

One oddball in the performance league points out a relatively new trend that has had an enormous impact on the auto industry—the so-called “crossover market,” where trucks substitute for cars, rather than being used exclusively as load-haulers.

Take the 454 SS Chevy pickup truck, which has had a 7.4-liter V8 stuffed into the engine bay of a C-1500 pickup. The big block develops 230 hp and 385 lb.-ft. of torque, which actually exceeds the Corvette ZR-1's torque rating. After driving the 454 SS I got the strange feeling that this truck would be favored more by urban cowboys than the real variety of cow folk due to the abysmally low gas mileage of the monster engine.

Even compact trucks have been indulging in a horsepower race for several years. This year's entry is the four-liter V6 from Ford for the Ranger pickup and Aerostar minivan. The engine is based on Ford's 2.9-liter unit, with a lengthened stroke and a larger bore to up displacement to an even four liters. Power output is 160 hp, but more impressively torque has been boosted to 240 lb.-ft.

The Ford V6 shares the engine spotlight with Chrysler's new 3.3-liter V6 designed exclusively for passenger cars. Both employ a relatively conventional 60-degree angle between cylinder banks, pushrod valve actuation, cast-iron blocks, with technical updates like sequential-port electronic fuel injection and roller valve lifters. It's worth noting that Chrysler's new V6 is only the first in a series of engines based on the same block, with turbocharged and multivalve versions on the way.

Upcoming on the domestic front is a flurry of activity. GM's Saturn Division is close to production of the first car engineered in the United States from scratch since the mid-1960s. Ford's new modular engine program promises a sorely needed new lineup of power plants for that company, and Chrysler is working out the details of its new platform.

One advantage currently held by U.S. car makers is fuel economy, such as Chevy's new Lumina that has a 29-mpg EPA highway rating. Today many import models have grown in both bulk and power, with corresponding fuel penalties. For example, the 1990 Honda Accord weighs in nearly a half-ton heavier than when it was introduced 12 years ago. Along the way, fuel econ-

omy has steadily dropped from 38 mpg to the 1990 model's 23 mpg.

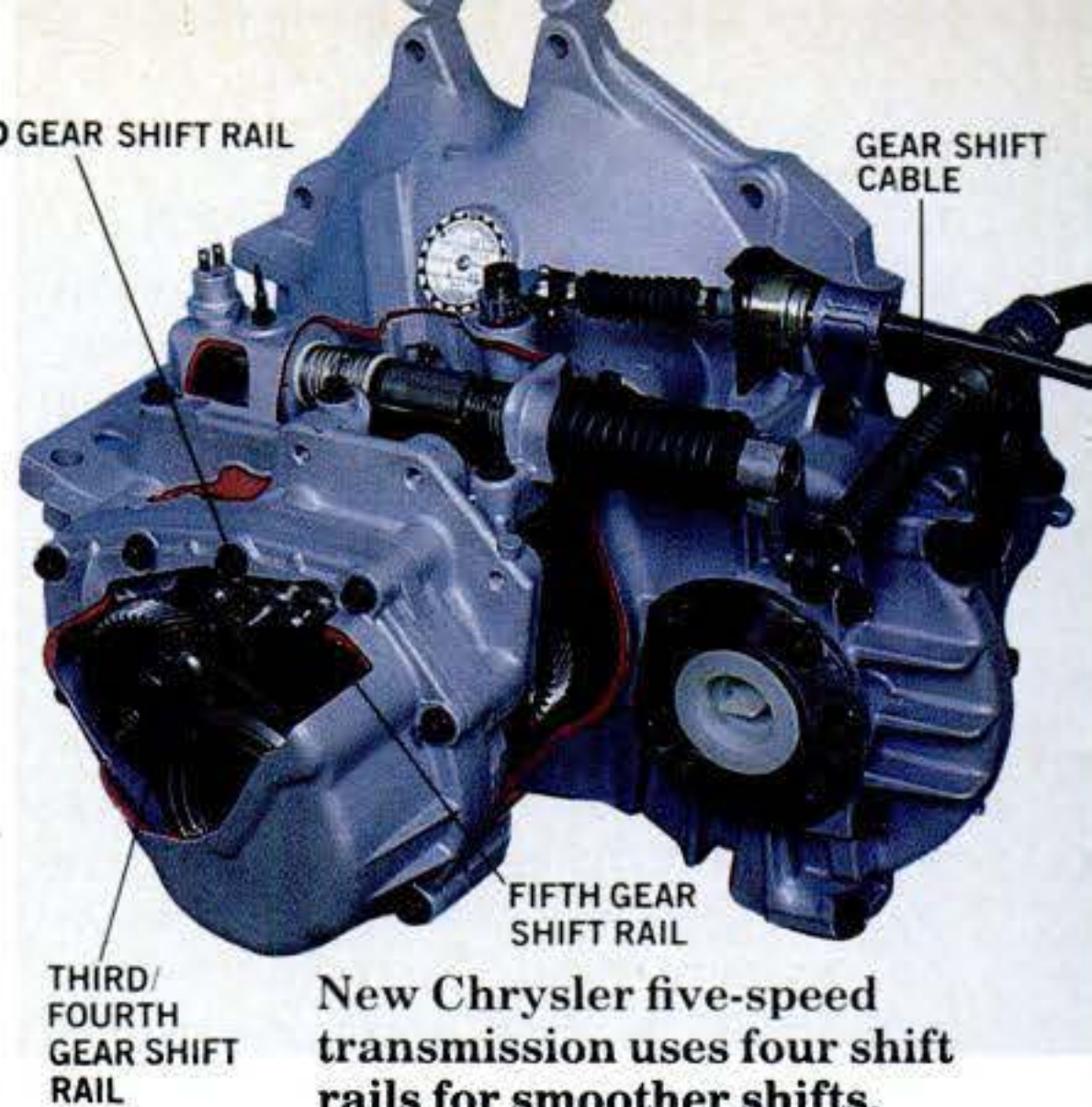
The result is a kind of convergence, where there are more similarities than differences between today's domestic and imported cars, although domestic engineering today is sticking with mechanically simpler designs on its mainstream models.

The race is getting tougher, the differences smaller, and the outcome more difficult to predict. Considering the growing similarities between cars, perhaps the question should be rephrased: “What car is state of the art?” not “What country?”

PS

FIRST/SECOND GEAR SHIFT RAIL

GEAR SHIFT CABLE



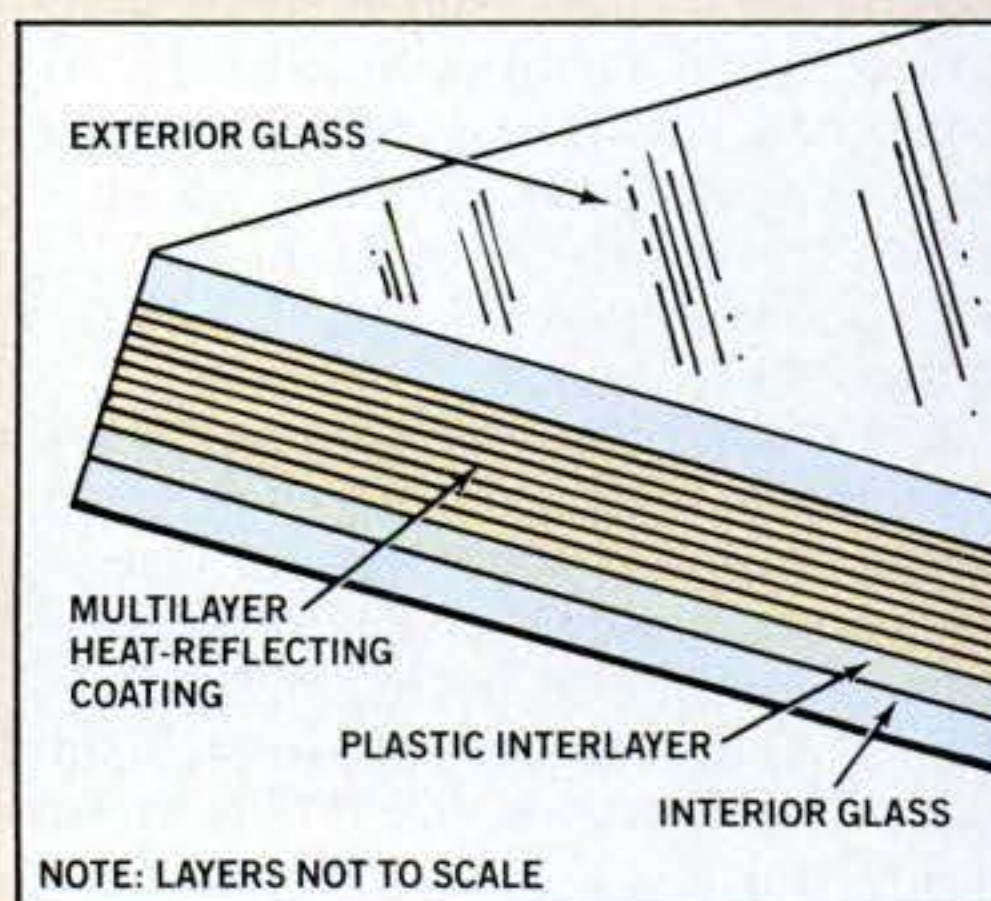
New Chrysler five-speed transmission uses four shift rails for smoother shifts.

SUN STOPPER

With a 19-square-foot windshield—by far the largest of any car or minivan on the road today—the Chevrolet Lumina APV faces a constant battle with the sun. Thermal overload results when the sun's heat-carrying infrared radiation overwhelms the vehicle's cooling system. The solution is either to upgrade the vehicle's air conditioner to compensate for the extra load or engineer a glass that selectively blocks the sun's heat energy, but remains transparent. Chevrolet, along with PPG Industries, developed a multilayer laminated glass product called Sungate that reflects or absorbs 60 percent of the sun's thermal energy striking the glass surface, according to Rudy Malobicky, PPG's product manager for automotive products.

“The key is a 1,500-angstrom [six-millionth of an inch or about 1,000 times thinner than a piece of paper] layer of silver applied to the glass surface that reflects the sun's heat energy,” says Malobicky. Over the silver are multiple layers of oxides of zinc, copper, and titanium each less than 200 angstroms thick to form a highly effective multilayered heat filter (see drawing). You can't see the silver layer because these ultra-thin intermediate layers smooth the transition of refractive index between the silver and glass: “It's like bridging the gap in little steps, not in one huge jump,” explains Malobicky.

Tests, using thermal imaging of the van's



interior, show that Sungate glass kept the vehicle between 5 and 10 degrees F cooler than standard glass, according to PPG.

To layer glass precisely with a variety of metals, a process called vacuum sputtering has been adapted from the computer chip industry. Inside a 100-foot-long vacuum chamber the glass pieces that make up the exterior sheet of glass, looking like large clam shells, are lined up and bombarded with atoms corresponding to the various metals desired. These atoms coalesce to form the fine layers needed. To that the interior glass sheet is attached with a plastic interlayer that will keep the glass from shattering in the event of an accident.—Brian Nadel



The aggressively styled Chevrolet Geo Storm is an Isuzu-built two-seater powered by a 125-hp double-overhead-cam four-cylinder engine.

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DO-IT-ALL HEAT PUMPS

Two new heat pumps use waste house heat to give you free hot water in summer. In winter, when they're not working full time, they heat water more efficiently than electric resistance. The machines share some engineering similarities, but are distinguished more by their differences.

By MARIETTE DiCHRISTINA

Wayne Reedy can't imagine being anything but a heat-pump engineer. With a father in the refrigeration business, he grew up with the idea. "I've never wanted to do anything else," he says.

Reedy's dedication has made him an important figure in what may be one of the most significant advances in heat-pump technology since the machines were introduced in the late 1950s: fully integrated water heating. Two new machines, the Mac=Pac made by Artesian Building Systems and Carrier Corp.'s HydroTech 2000 [Feb.] provide this capability at high efficiencies. And Reedy, vice president for engineering at Artesian, has worked on both.

Heat-pump primer

Heat pumps essentially are air conditioners that can run backward. They have a reversing valve that switches refrigerant flow to bring heat from outside air into your home in winter. They are more efficient than electric-resistance heating because they use electricity to move and enhance heat, not just to create it.

In the past, there were two ways to channel the efficiency of a heat pump for domestic water heating (the third biggest energy user in a home after heating and cooling). One was a dedicated heat-pump water heater [April '80], which works well in many climates. But the machines take up

space, are expensive, and take no advantage of waste heat from a heat pump's cooling cycle. Another machine, a waste-heat water heater, does only that [Aug. '80]. But these add-on devices add complexity, are costly, and cut the heat pump's basic efficiency.

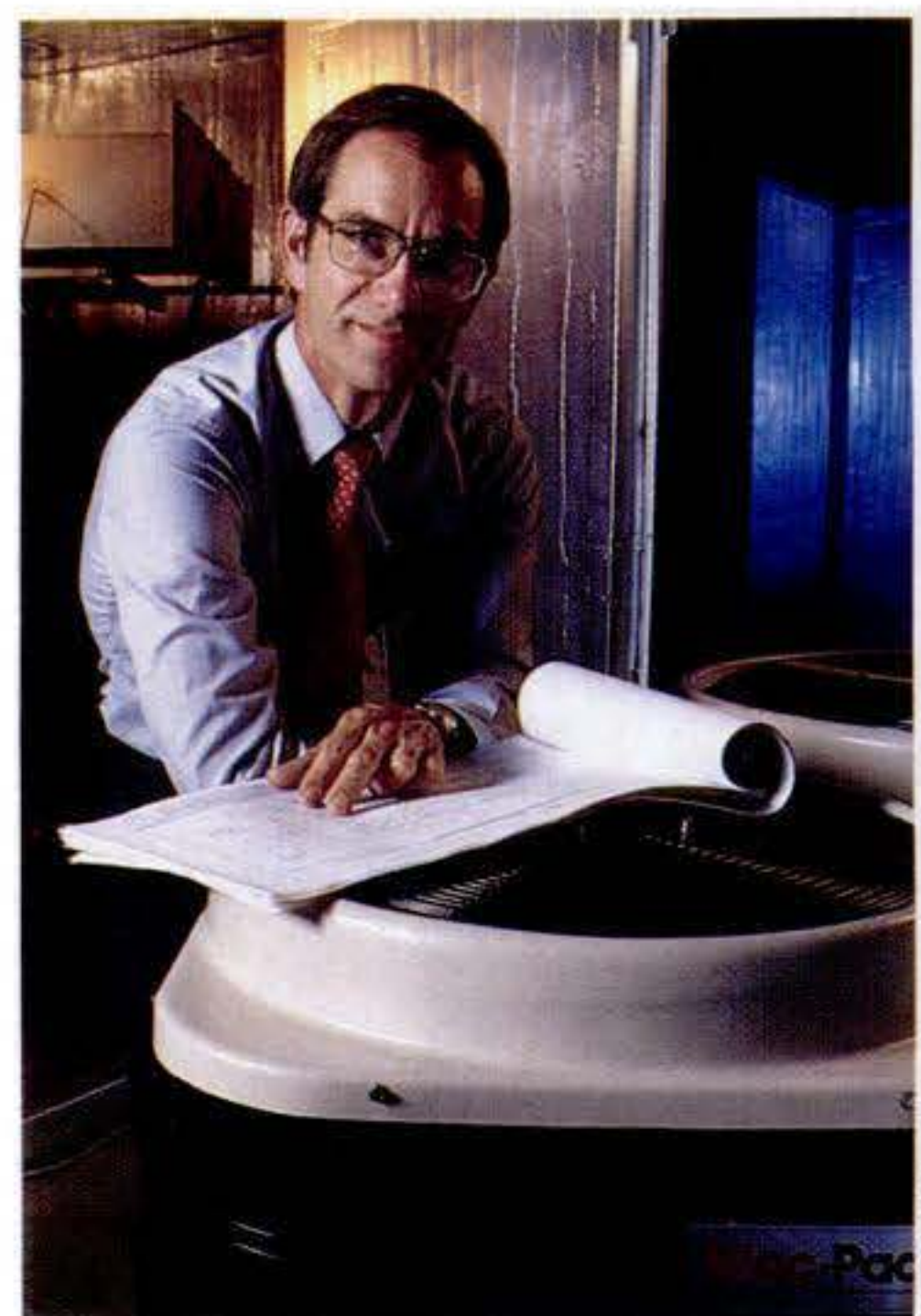
With the HydroTech and Mac=Pac, water heating is an integral part of the operation. Thus, a single machine provides water heating, space heating, and air conditioning.

The two share some similarities. Both bring the compressor indoors, easing winter trouble-shooting and reducing outdoor noise. Both can be used with an existing hot-water tank, though Artesian also sells a Mac=Pac with a built-in tank (see illustration).

The machines' cleverness lies in basic design simplicity. The extra modes have been incorporated without much altering the standard heat-pump layout. The chief exception is a second refrigerant line for HydroTech's novel defrost cycle. The line lets the machine borrow heat from the hot water to melt ice on the outdoor coil in the winter (see captions).

The Artesian and Carrier systems (which received patents within a few months of each other) were developed without either company knowing of the other's work—and under different philosophies.

Mac=Pac grew out of research that indicated greater energy savings were possible with integrated systems. (The name derives from "mechanical pack-



Engineer Wayne Reedy, whose name appears on a patent for the HydroTech heat pump that was taken out when he was a Carrier researcher, now works on product improvement for Artesian's Mac=Pac.

age.") "We decided," says Artesian's president, Maurice Rice, "that, as far as we could, we'd keep it simple and use available, proven technology."

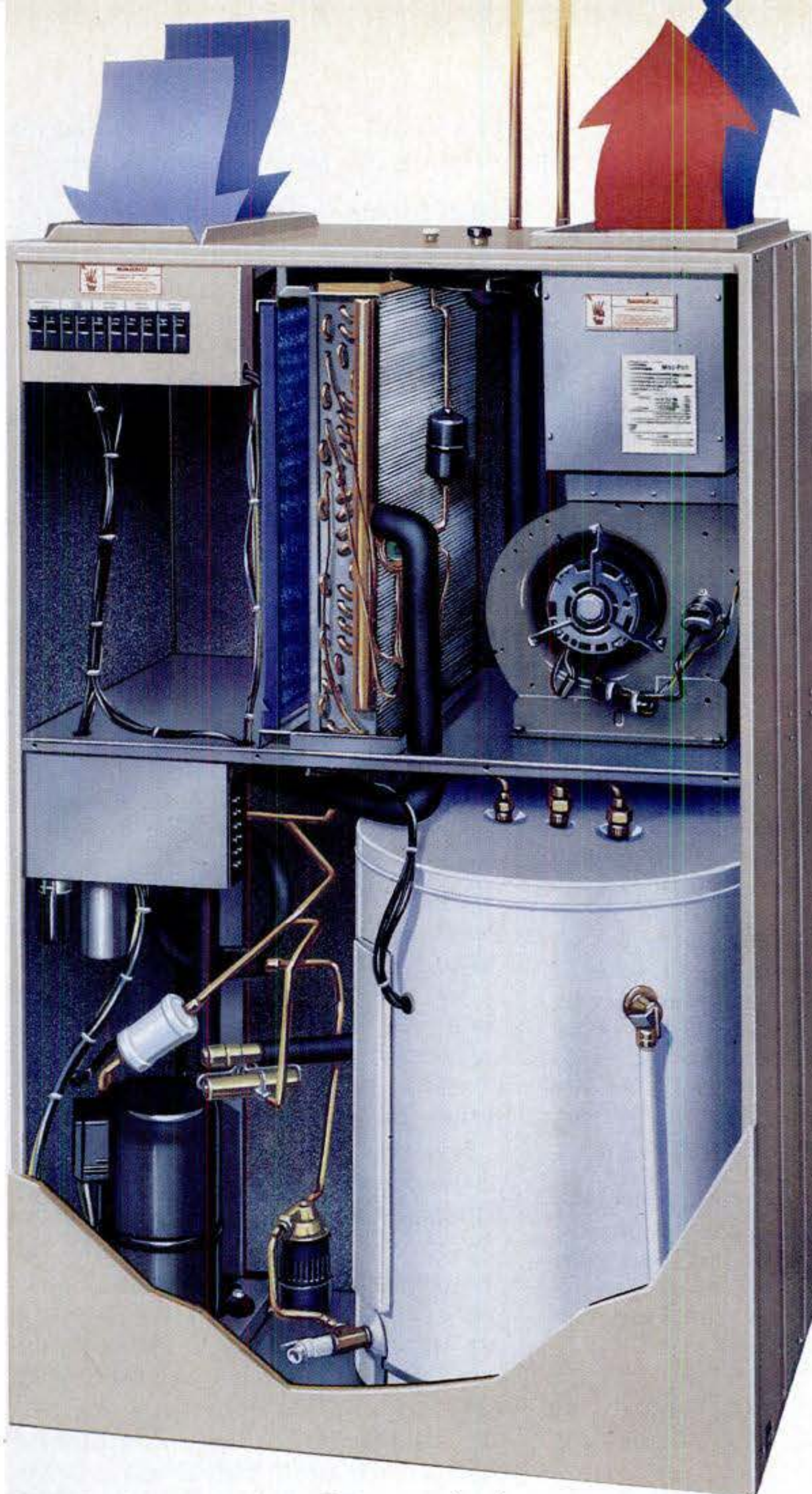
HydroTech had a different genesis: It's a product of a no-holds-barred six-year \$6.5-million joint research effort by Carrier and the Electric Power Research Institute.

Now in charge of future development for the Mac=Pac, Reedy was lured to Artesian in Lafayette, Ind., after his research group at Carrier was disbanded. There, he tells me about the problems of adding water heating to the heat-pump cycle.

Reedy juts over his orderly desk and stabs with slender fingers at the refrigerant-flow diagram between us. "This is a standard heat pump," he says in rich, precise tones. "It's where everybody starts." He draws a water tank outside the flow path. "Now, to integrate water heating without the system becoming too complex and expensive, and have it work under all conditions, well, that's a trick.

"The most obvious way to add water heating," he continues, "is to put in a separate refrigerant line from the compressor, through the heat exchanger, and reattach it to complete the circle." He pencils in the connections.

"Then you need a solenoid valve to switch the water heating on and off," he says, adding that to the drawing. "That's fine, except that when you're not heating water, refrigerant will liquefy and accumulate in the heat ex-



MAC=PAC

The Mac=Pac heats water with excess capacity in winter and waste heat from the house in summer. The refrigerant circuit is standard, except for the addition of a desuperheater (below).

In winter (red), the refrigerant, a low-boiling-point fluid, boils in the low-pressure outside coil, then acting as an evaporator. The resulting gas travels on to the compressor, where its temperature and pressure are boosted. The gas then enters the desuperheater, a heat exchanger, where some heat is transferred to cold water piped from the bottom of a water-heater tank. The desuperheater removes only superheat: that above what it takes to keep the refrigerant in gaseous form. The refrigerant, still hot and a gas, travels to the inside coil, where it condenses, giving up heat to the house. Space heating takes precedence over water heating. When the house's heat needs about equal the capacity of the heat pump, a control shuts the supply of water to the desuperheater, and the water is heated by backup electric elements. Backup resistance heat also supplements the heat pump for space heating.

In summer (green), hot refrigerant gas from the inside coil, now acting as an evaporator, is further heated and pressurized by the compressor. The gas enters the desuperheater, where some waste heat is transferred to the tank's cold water. The refrigerant continues to the outdoor coil, where it dumps more heat to the outside air as it condenses. The now-liquid refrigerant passes through an expansion valve into the low-pressure evaporator, where it boils, picking up heat from the house, and becomes a gas again.

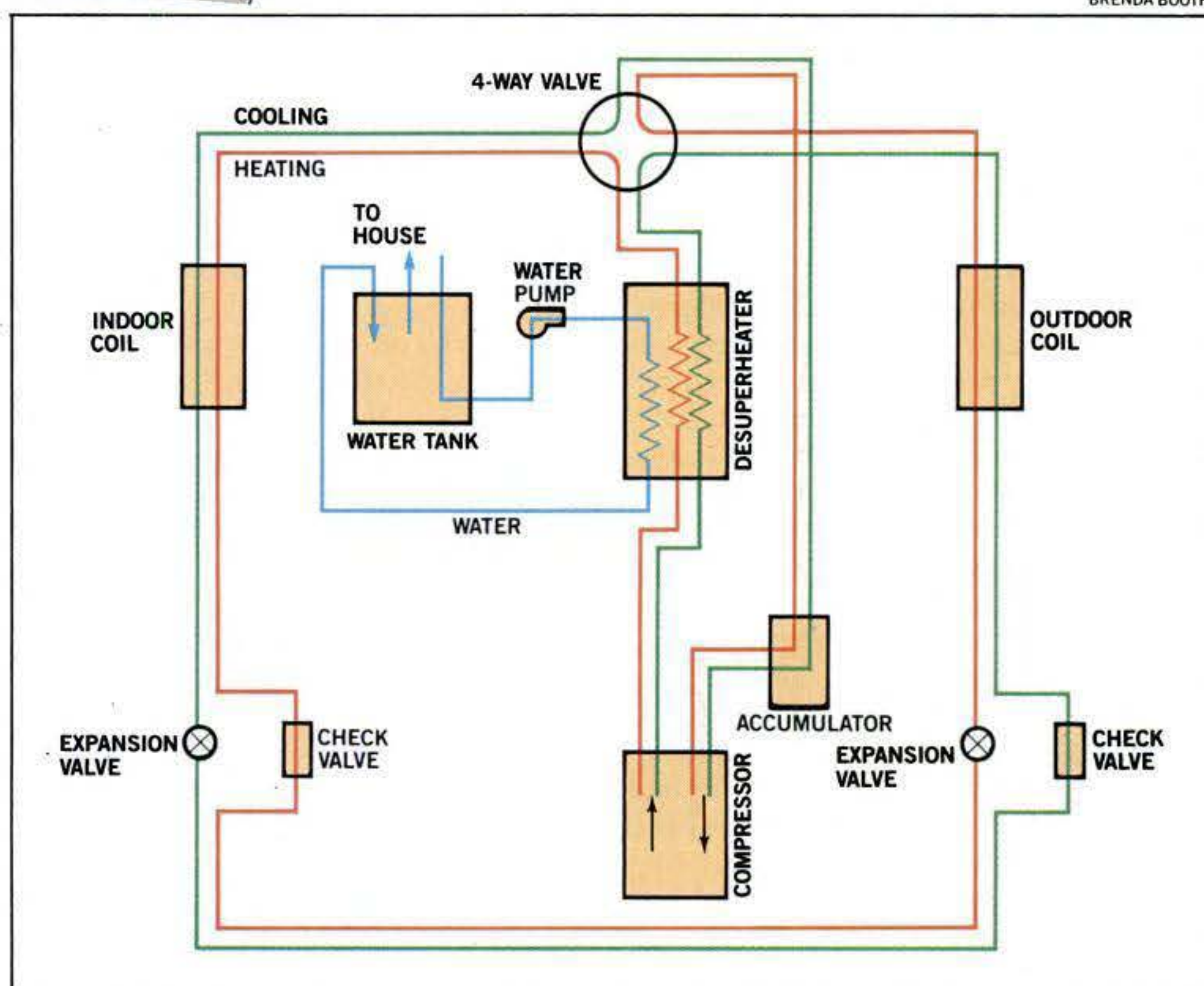
changer because it's not being pushed along by the compressor. A check valve will stop this by preventing the refrigerant from backing up [he draws one in]. But even then, some refrigerant will get trapped between the valves when you're not heating water. To draw off this refrigerant, you can add a capillary tube and hook it into the suction side of the compressor." Soon Reedy has made a knot of the hypothetical heat pump. "You see," he says, "now we've got all these extra valves, and we've still got problems."

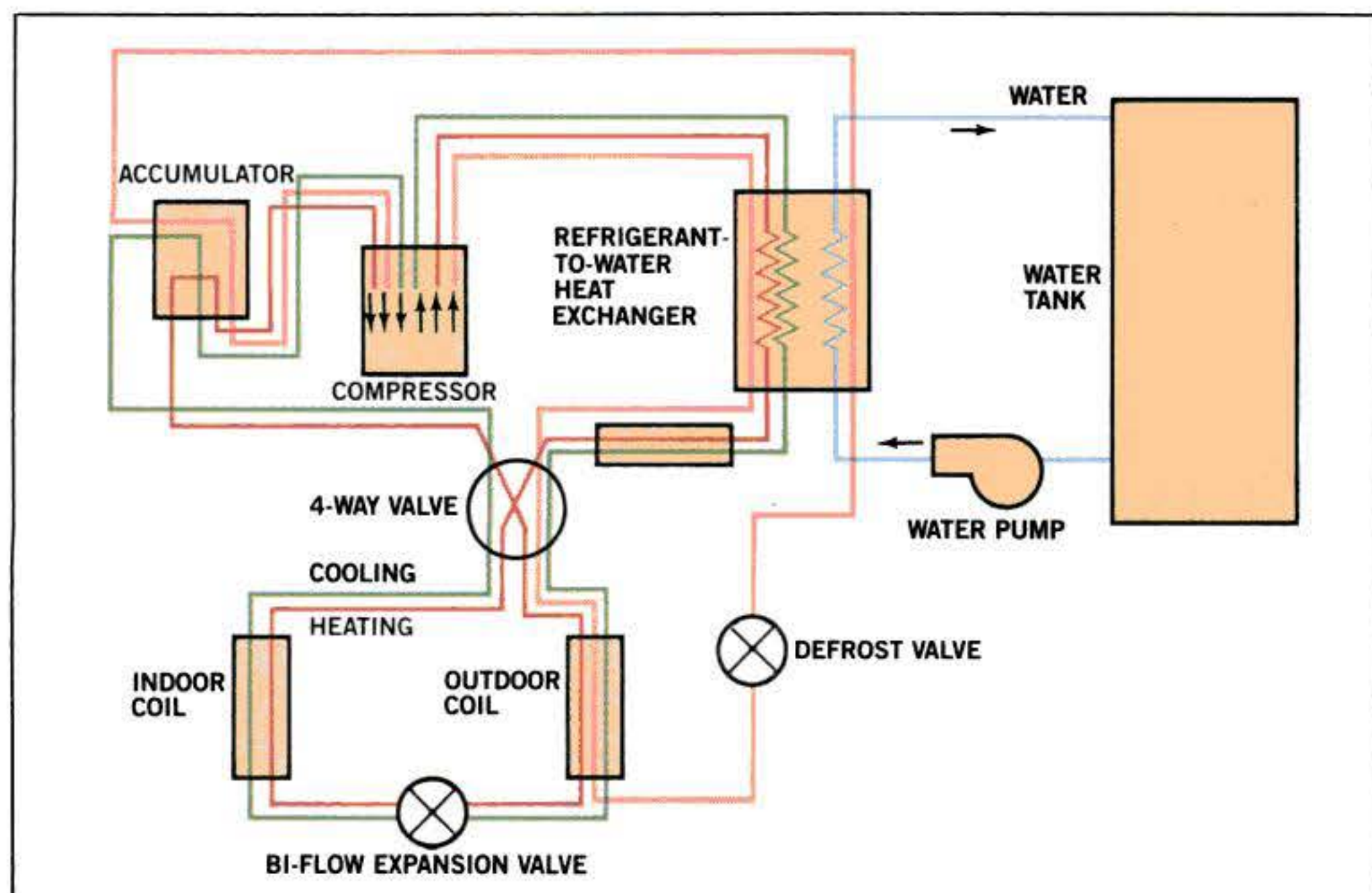
"But by putting the heat exchanger in the same compressor discharge line as for the other modes, you make sure it always has hot refrigerant vapor in it and won't accumulate liquid," Reedy says. "It's as simple as that."

Arvo Lannus, manager of residential programs at EPRI, agrees: "It's very easy to create a complicated flow scheme that requires many valves—each adding to pressure drop, cost, and potential for failure."

Continued

BRENDA BOOTH





HYDROTECH 2000

Carrier's HydroTech 2000 provides hot water when it is cooling or heating—or neither—and adds a novel defrost.

In summer (green), hot gas from the compressor goes to the refrigerant-to-water heat exchanger, where it desuperheats and condenses, dumping most of the waste heat, then on to the outdoor coil, to release the remaining heat. The liquid refrigerant evaporates in the indoor coil, absorbing heat, and returns to the compressor.

In winter (red), hot gas from the compressor goes to the refrigerant-to-water heat exchanger, transferring some heat.

EPRI's first patent for the Carrier HydroTech (which is in Reedy's name, by the way) used just four refrigerant-control valves: a reversing valve, a unique electronic pulsing two-way, or bi-flow, valve, an expansion valve, and two check valves—one allowing gas to run in the heating or cooling modes and one for defrost.

But more significant is the subsequent EPRI patent by Carrier researcher Kevin Dudley, says Harry Hale, Carrier's director of corporate engineering services. In the patent, which embodies the production design, the refrigerant flow was reworked to drop one check valve, making the total three. "The simplification of the refrigerant circuit improved cost and reliability," explains Hale.

The machines' differences really show up in their components. Artesian chose conventional parts to fit the company's emphasis on cost, simplicity, and reliability, says Reedy. "We had the same objectives," says Hale of the HydroTech, "but have also added many new-technology features."

The HydroTech, for example, uses a variable-speed compressor with mi-

The refrigerant continues to the indoor coil, where it condenses, giving up heat to warm the house. It passes through the bi-flow expansion valve (see text) and on to the low-pressure outdoor coil. There, it boils, removing heat from the air, and returns to the compressor.

When the house needs no cooling or heating, HydroTech acts as a dedicated heat-pump water heater. The gas flows in the same path as for heating. Backup water and space heating is from electric-resistance elements.

To defrost the outdoor coil (orange), refrigerant travels through a second circuit and is evaporated by heat from the water in the refrigerant-to-water heat exchanger. The water temperature is raised again afterward.

croprocessor controls that match the speed of the compressor to the heating or cooling load. This, coupled with a multispeed indoor blower, provides better dehumidification in the cooling mode, increases efficiency, reduces noise, and may improve reliability. "It's the starts and stops that kill a compressor," declares Lannus. While he acknowledges that the relatively new variable-speed technology adds complexity, he points out the benefits: "It's unbeatable in terms of comfort and temperature control."

The Mac=Pac uses a desuperheater, which removes some heat to warm water, but not enough to condense the refrigerant (see caption); thus, it provides hot water only when it is also heating or cooling. But the HydroTech can run as a dedicated heat-pump water heater. The reason: Its refrigerant-to-water heat exchanger takes advantage of the latent heat of condensation, which provides several times the heat energy of desuperheating. "When you don't need cooling or heating you still need hot water—for a shower or the dishwasher," says Lannus. "The only time HydroTech can't

provide all your hot water is when it's running full time to heat the house."

Ingenious defrost

During winter, when a heat pump's outdoor coil is acting as an evaporator, ice can form on it. So all heat pumps include a defrost mode.

The Mac=Pac uses a standard time-temperature system: Below a set temperature, the defrost kicks in at 90-minute intervals. The heat pump switches to cooling mode, taking heat from indoor air to defrost the coil, and using backup resistance heat to compensate for indoor temperature loss.

But a temperature sensor in the HydroTech triggers defrost only when needed. Then, refrigerant passes through the outdoor coil and follows a secondary line through the refrigerant-to-water heat exchanger to defrost the coil using stored heat from the water. "It's a nice feature," admits Reedy, "and one of the things in the patent with my name on it that I haven't been able to get around."

The HydroTech also has software that will enable utilities to slow the compressor, reducing the unit's power draw during peak times—but not interrupting space conditioning.

How do the machines compare in performance? The Seasonal Energy Efficiency Ratio (SEER), a standard measure for cooling efficiency, and the Heating Seasonal Performance Factor (HSPF), the equivalent for heating, are impressive for both. For a three-ton unit—enough to heat and cool an 1,800-square-foot home in a temperate climate—the Mac=Pac has an SEER of 10 and a HSPF of 7. HydroTech has a SEER of 14 and a HSPF of 9. There are no standard methods for crediting the efficient water heating that these machines deliver, but that considered, the effective efficiency would be considerably higher.

Plainly the numbers are better for the HydroTech. But that may not tell the whole story. A Mac=Pac (without built-in water tank) costs about 20 percent more than a conventional heat pump. Artesian says it will pay back in energy savings in two years. HydroTech costs about 50 percent more than other heat pumps—and Carrier claims a five-year payback. Throughout its life, however, the HydroTech would continue to function more efficiently than the Mac=Pac.

In any case, water heating offers much potential for energy savings. With better insulation and building techniques, Hale says, water heating could displace space heating and cooling as the top home energy user: "So I think this is the beginning of a series of integrated products." **PS**

HOUSE WARMERS

A remote-controlled fireplace door, a furnace that burns coal slurry, and an easy-to-install foam tank that not only stores hot water but also warms air. These are among the hot new products that will keep you warm this winter.

1 DISAPPEARING DOOR

How can a confirmed couch potato bask in the glow of an open fire without getting up to open the fireplace door? The same way he operates his TV: He pushes a button on a remote control, and the Gentry fireplace's door glides up a track and out of sight. The motorized Pyroceram glass PowerDoor costs \$633. More than 32 inches wide, it's the largest piece of glass made for fireplaces, claims Fondis Corp. (Box 6444, Edison, N.J. 08818).

2 PELLET BURNER

The antidote to autumn's chilly weather may be a cozy evening by the hearth, but an inefficient fireplace sends the heat up the chimney. Pyro Industries has one solution: an insert with the aura of a traditional fireplace and the efficiency of a pellet-fueled stove.

The Whitfield Advantage II is designed to slip into existing fireplaces, but can also be installed in any outside wall with minimal masonry work. Says Eben Hedman, customer service manager for Pyro, "Two feet of horizontal vent is all you need."

The stove burns biomass pellets, inch-long capsules made of compressed wood or other kinds of cellulose. Because of their low moisture content—three to eight percent—they burn intensely. "A ton of pellets requires sixty-four cubic feet of storage space," says Hedman. "That's half the size of a cord of firewood, but it produces one and a half times the heat output." This efficiency means less fuel is converted to ash; the stove produces only 1.3 grams of particulates per hour, well below federal standards.

Whitfield inserts and free-standing stoves are available from dealers nationwide.—*Judith Anne Yeaple*



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3 THREE-VIEW HEARTH

You can watch the flames from three sides of this Swiss fireplace. But because the Rüegg Prisma is wrapped in an angled one-piece thermal glass pane, its good looks manage to make good sense. "You get both the beauty of an open-hearth fireplace and the heat output of a wood stove," says Rüegg vice president Linda Alber.

The Prisma not only looks like an open hearth, but it also converts to one. The entire piece of glass slides up behind the fireplace's facing, says Alber. "A locking mechanism also allows the whole piece to swing open from the left side," she says. Easy access and a built-in ash bucket mean easy cleanup.

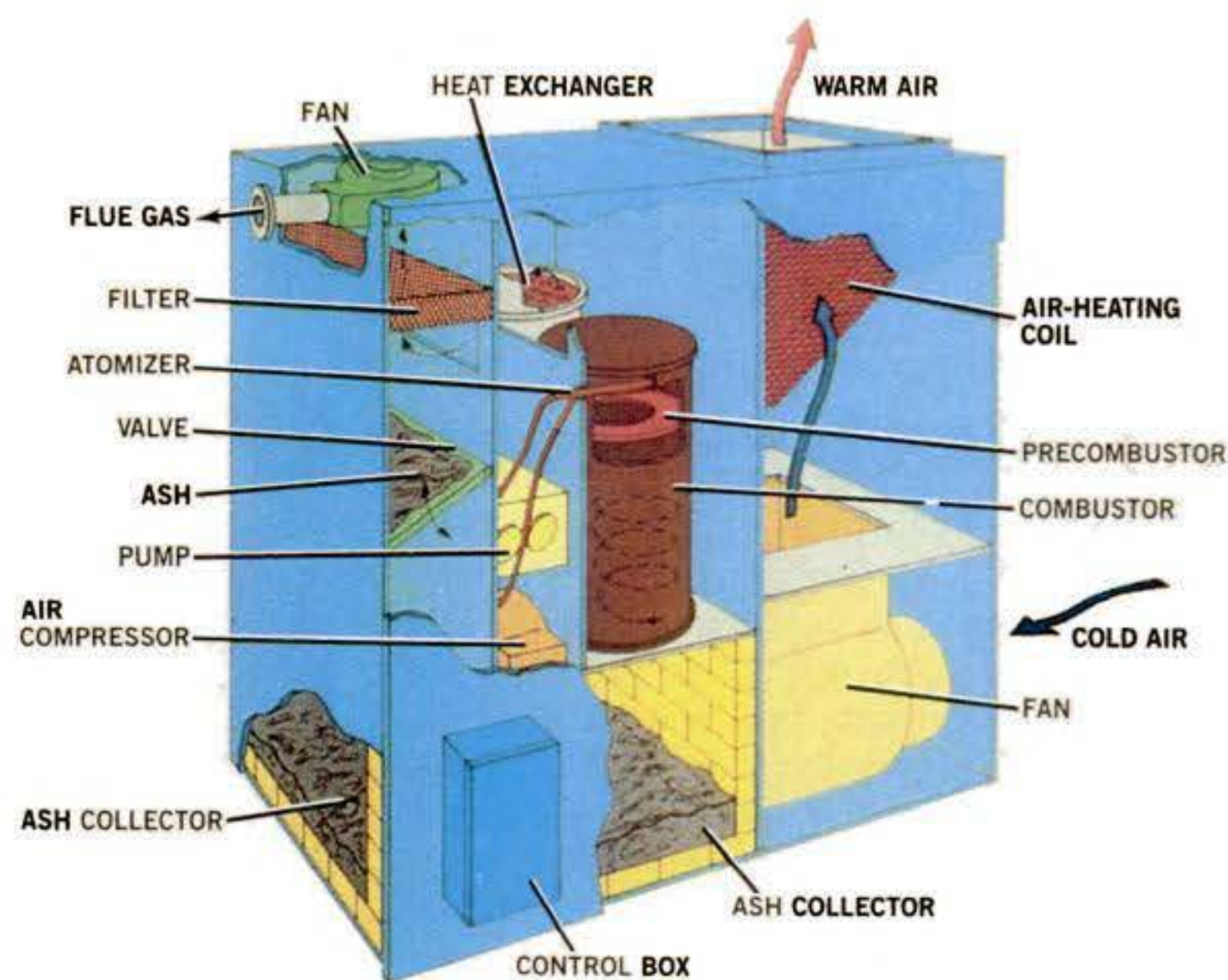
With its door closed, the \$3,500 Prisma produces up to 55,000 Btu per hour. It heats a mixture of indoor and outdoor air, which helps prevent rooms from becoming too hot and dry. A five-speed blower circulates the fresh air around the room. Rüegg Fireplaces, 976 Route 22 E., Bridgewater, N.J. 08807.—*Marcelle M. Soviero*

4 I'M OK, YOU'RE OK

Tap a key to let this "sensitive" remote control know how you feel at the moment: "too cool," "okay," or "too warm."



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When the room reaches the desired temperature, the "I feel control" memorizes the setting and recalls it whenever you use the system again. The controller works with a Mitsubishi Electric air conditioner and several of the company's heat pumps.

5 COAL COMEBACK

Just when you thought residential coal furnaces had become museum pieces, new technology may bring them back. Tecogen, Inc., of Waltham, Mass., has designed a coal furnace that offers the convenience of an oil furnace but doesn't rely on petroleum-based fuel.

Rather than burning lumps of solid coal, Tecogen's prototype uses a coal slurry, consisting of finely crushed coal combined with water and additives. Frederick Becker, director of energy technology at Tecogen, says that the slurry-making process "removes a lot of ash and sulfur, making the coal a higher-quality fuel."

The slurry is as convenient to store as oil but doesn't burn as easily. "The problem is that you have to evaporate the water first, then raise the temperature of the coal," says Becker. "We needed a device to keep the fuel in the combustor until it can burn."

The solution: Tecogen engineers

invented the Inertial Reactor with Internal Separation (IRIS). It blows air into the combustion chamber, creating a swirling vortex. Coal particles are trapped in this miniature cyclone until they burn completely. "The IRIS provides high efficiency in a small volume," Becker explains.

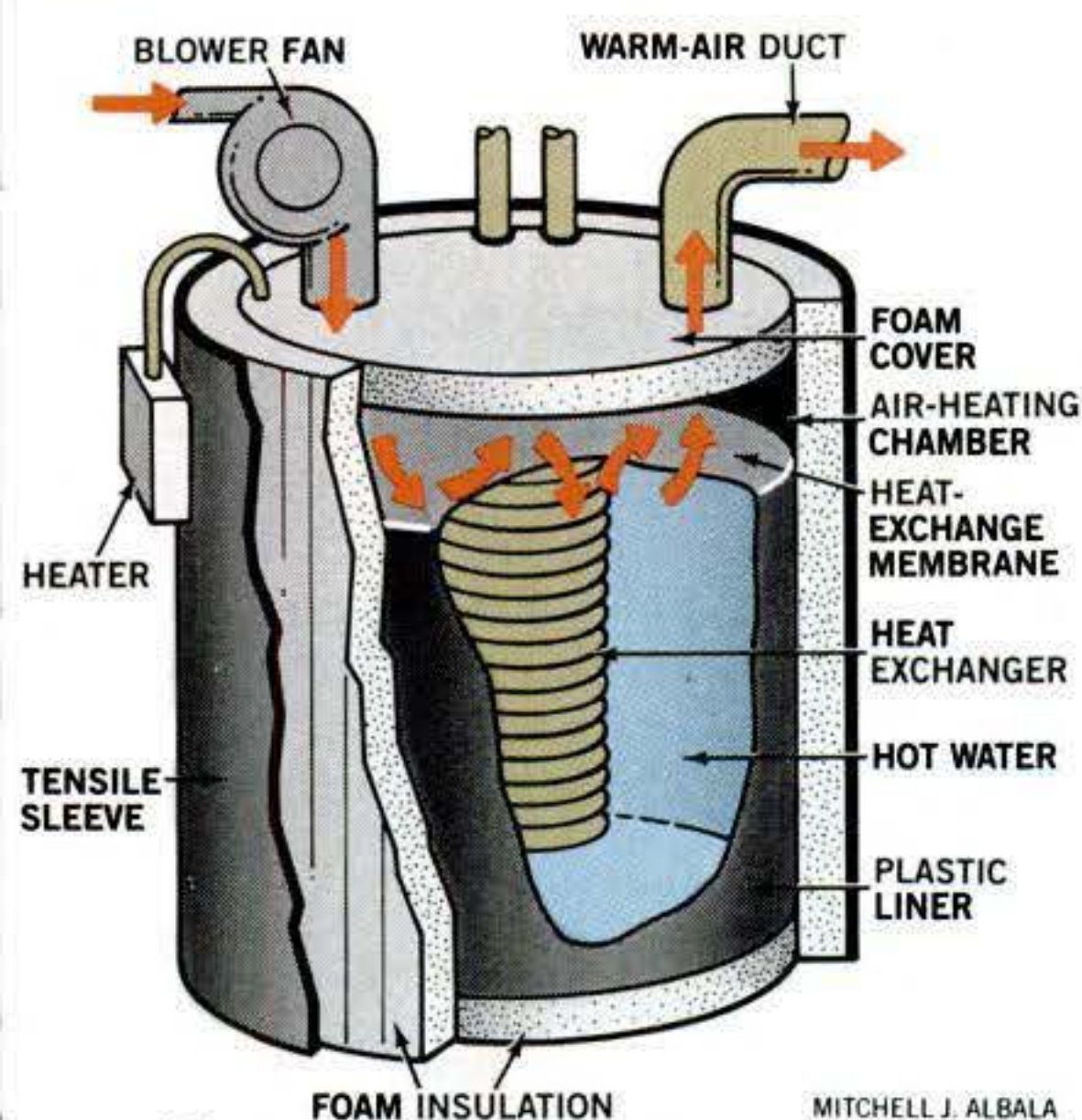
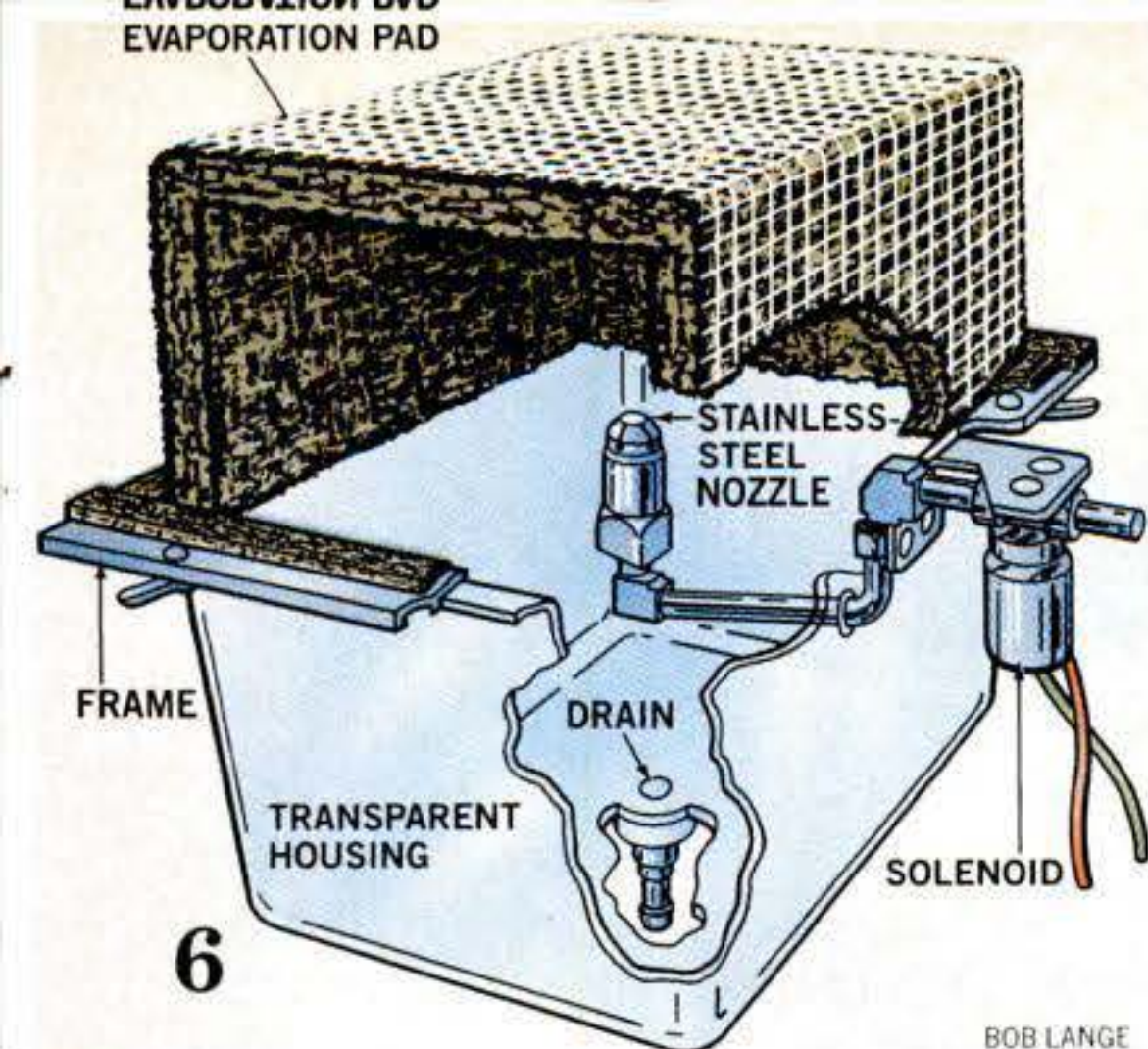
The four-foot furnace is cleaner than its hulking predecessors. A two-step filtering system catches ash so well that "the emissions are almost completely particulate-free," claims Becker.

Tecogen has not announced when the furnaces may be commercially available.—*J. A. Y.*

6 COOL-AIR HUMIDIFIER

Ordinary furnace humidifiers depend on blasting heat and circulating air of at least 140 degrees F to evaporate water. But today's efficient furnaces and heat pumps often run at temperatures too low for that to work. So Nu-Air Corp. has produced a humidifier that atomizes the water first. The droplets can then be evaporated easily, even by 80-degree-F air.

The Nu-Klean humidifier is mounted in the ductwork as close to the furnace as possible. An atomizing nozzle sprays the water at 40 psi onto a boxlike pad that holds the droplets for evaporation.



Made of natural materials, the pad also traps minerals like calcium and iron that would otherwise end up as white dust. Unevaporated water falls to the bottom of the unit and drains away.

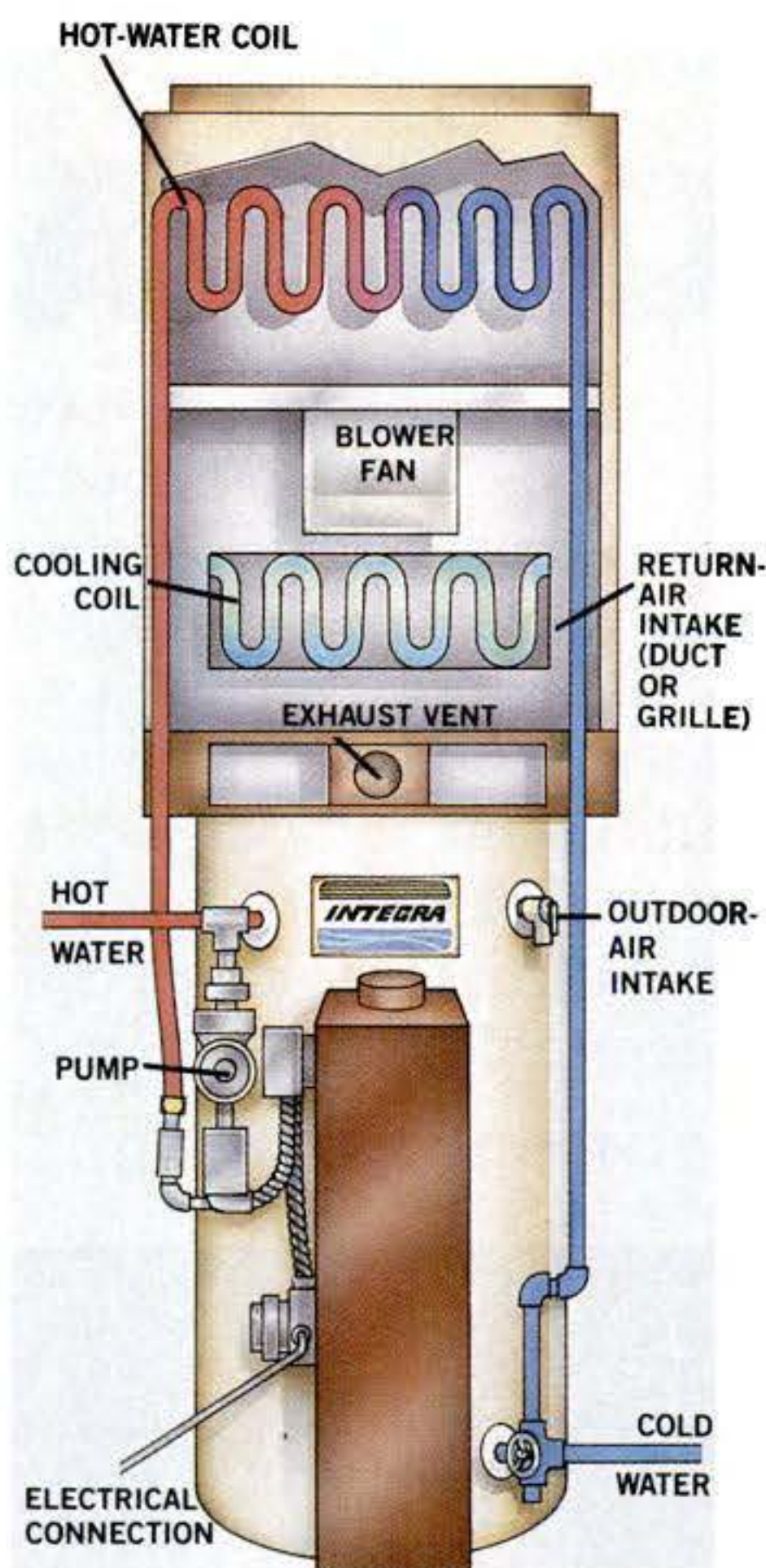
A homeowner can install the humidifier in one to two hours, according to the company. The 24-volt model with humidistat costs \$147. Nu-Air Corp., Box 1145, Bloomington, Ill. 61702.—*Nancy Negovetich*

7 TANK UP ON HOT AIR

Access Technology's lightweight, flexible tank was originally intended to store water heated by a solar collector. And it's currently being sold with the Copper Cricket ["Solar Heat With Perks," July]. But since the demise of solar tax credits, the Softank's designers have been using it to store water heated by other sources, particularly off-peak electricity. Now they've found an additional use for the tank: as a water-to-air heat exchanger.

The tank has three components: a plastic liner, an insulating shell made of polyethylene foam, and a plastic tensile sleeve. It comes preassembled and folded into a box. "You can throw it in through a basement window," says Tom Gocze, president of Access.

To adapt the tank for heating air,



8

Gocze and his colleagues poked holes in the foam cover and attached a fan. It blows air across a membrane, made of the same plastic as the liner, that floats on top of the water. "The plastic is cheaper than copper, but it's so thin that it conducts heat readily," says Gocze. So the water, which is hottest at the top of the tank, releases heat to the turbulent air passing over it. The system is being tested at the University of Maine in Orono and will be on the market by the end of the year, says Gocze. Access Technology Corp., 360 Center St., Bangor, Maine 04401.—*Dawn Stover*

8 TWO-IN-ONE HEATER

Making a water heater do two jobs—heating both water and air— isn't a new idea. But until recently, integrated water/space heaters have been large, expensive units that had to be installed within a few feet of an exterior wall. The Mor-Flo Integra doesn't have these drawbacks.

The heater uses outdoor air for combustion, pulling it in through a two-inch-diameter PVC pipe. Exhaust gases are sent back out through the wall. "The gases never come in contact with indoor air," says Gary Bosma, vice president of sales at Mor-Flo Industries

HOME HEATING



9

(18450 S. Miles Rd., Cleveland, Ohio 44128). The sealed system means it's safe to install the Integra up to 25 feet from an outside wall.

The ignition system is another safety feature. The Integra doesn't use a pilot light. Instead, electricity heats a tungsten carbide loop to ignite the gas. "If the flame is lost, the system shuts off the gas," says Bosma. The Integra's \$1,800 cost and vertical configuration make it attractive for apartments as well as houses.—*Janet Donnelly*

9 AIR CARE

Mounted on the wall beside a thermostat, this indicator monitors a home's electronic air cleaner. The "on" light assures the homeowner that the cleaner is working properly. "Wash" means the collector cells are dirty. And "check" lights up when the air cleaner malfunctions.

Made by Honeywell, the W8600E solid-state performance indicator can be ordered with the company's F50E air cleaner. It's intended to be installed in a new house at the same time as the matching thermostat. The device will help draw a potential buyer's attention to the indoor air cleaner's capabilities, says Honeywell. The indicator costs \$30 to \$40 installed.—*D. S.*

BALLOON DAMPERS

These clever devices give you a new way to zone a forced-air heating or cooling system. They're cheaper than motorized dampers, equally automatic, and easier to install. Balloons in your ducts can mean substantial savings—but their big benefit is a more comfortable home.

By EVAN POWELL

PHOTOS BY JOHN B. CARNETT



Rubberlike dampers seal ducts as they fill with air—via a pump, fortunately.

them is tedious: You cut out a section of metal duct at each branch run and insert a damper. In newer homes with flexible ducts, you have to install sections of metal ducting to hold them.

Before the Airzone system came along, I had installed manual dampers to divide my home into living and sleeping zones and maintained the latter at cooler temperatures in winter. These dampers balance airflow, but do not open or close zones.

They did save energy, but left a problem: A room on the north side of the house that has glass on two sides was always too cold in winter and too warm in summer. Even adding a third supply duct didn't cure the problem

—but the Airzone system did. The reason: By cutting airflow to areas that don't need it, there's now more available for that room. In effect, I've increased the capacity of my furnace and air conditioner. In larger houses, zoning can mean that one heating or cooling system will suffice where two would be required without it.

The inventor of the FlexDamper, Jerry Tartaglino (now president of Enerzone), set out to solve his own problem. Then a regional manager for a company that installed energy-management systems in large commercial buildings, Tartaglino wanted a scaled-down version in his own house. "I lived alone and didn't want to heat and cool the whole place," he says. But when he analyzed his ducting and priced motorized dampers, the cost was prohibitive.

He's not sure how the idea of inflatable dampers came to him, but he started experimenting. "I stuffed kids' punching bags into the ducts, and rigged a compressor from a little tire inflator," he recalls.

When this inventor talks about losing sleep over his ideas, he means it. "Several times I was awakened by explosions," he relates. "You can't imagine how well noise carries through ducts until you have a big boom in the middle of the night." Those punching bags burst after a few inflation-deflation cycles.

Nevertheless, Tartaglino applied for and got a patent on the inflatable-damper concept, and eventually got two \$45,000 development grants from the Department of Energy.

One of the biggest barriers to commercialization was UL approval, Tartaglino reports. Eventually, he interested Du Pont in his concept, and that company developed a synthetic elastomer material that could undergo indefinite inflation cycles (no more midnight booms) and would not contribute toxic gases in case of fire. The now-UL-approved material, which Du

Chances are most rooms of your house are empty at any given time, yet your heating and cooling system probably sends as much of its output to the empty rooms as to those that are occupied.

That's only one problem with standard forced-air heating and cooling. In some houses there are others: An upstairs may be perpetually overheated unless the downstairs is kept uncomfortably cool. A south-facing room may be too hot every sunny afternoon. Or the kitchen may be oppressive whenever someone's cooking.

The answer to all these problems is to divide the house into zones that you can heat and cool separately. With hydronic (hot-water) heat distribution, zoning is a common practice.

Now, with a new system developed by Enerzone Systems Corp. of Dallas, it may become more common with forced-air distribution too. The system, called Airzone, uses inflatable dampers in the ducts. When a zone's thermostat calls for heat (or cooling in summer), the Flex-Dampers are deflated, allowing the air to flow through freely. Meanwhile, dampers in ducts to zones that need no conditioned air are inflated by an air pump, puffing up to block airflow. Solenoid valves and a control panel run the show.

The Airzone system can be used with a heat pump as well as with gas, oil, and electric furnaces, and with air conditioners. I installed one in my house and have found it to be the best answer yet to maximizing both efficiency and comfort. The Airzone equipment is relatively inexpensive, and installation is simple enough that most homeowners can do it themselves.

While zoning a hydronic heating system is easily done with valves, to zone a forced-air system you have to install motorized dampers. They work, but they're expensive, and installing

Pont calls Hytrel, has survived a million cycles in lab tests.

The FlexDampers themselves have been successfully tested through hundreds of thousands of cycles. Unlike a balloon, they do not stretch when inflated. The air fills the space between inner and outer membranes.

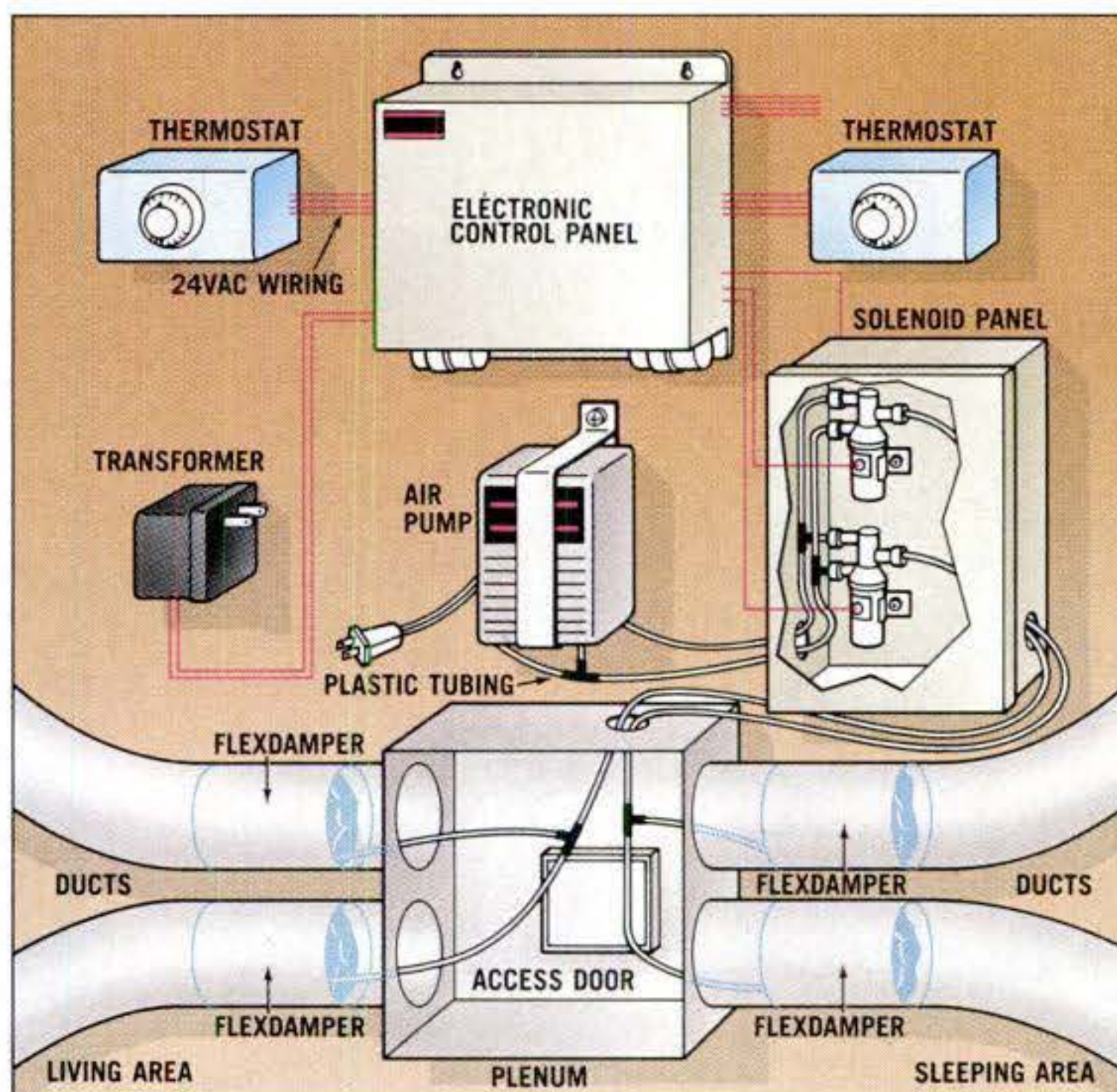
With the Airzone system, you can separately heat and cool anywhere from two zones on up. Enerzone sells two- and three-zone systems off the shelf (which you can combine to serve four or five zones). For larger installations, the company custom-makes a single panel containing the necessary solenoid valves.

The Airzone air pump is electrically connected to the heating and cooling system and turns on any time it does (in response to a thermostat, as usual). The pump has a suction port and a pressure port, both of which are attached to the solenoid valves. The valves can send pressure through the air lines to inflate the dampers, or suction to deflate them. "Since the pump stays energized, if there's a leak in a damper it is transparent to the system," Tartaglino points out. Enough air is pumped to keep even a leaky damper inflated. A pressure-relief and a vacuum-relief valve in the solenoid panel bleed off excess air.

Zoning a forced-air system can cause a couple of problems—both solvable. It may increase the noise at registers. "When you shut off half the ductwork, you're moving basically the same amount of air through a smaller volume so you may get increased noise," Tartaglino points out. The solution? Install a bypass—a duct with a barometric damper to connect the supply and return plenums directly. Then excess air can be routed there.

A bypass duct can also solve another potential problem: too little airflow over a furnace's heat exchanger or an air conditioner's evaporator coil. "With a two- or three-zone system we've never found it to be necessary," Tartaglino states, "but with more it could be." If you do not use the triangular sealing inserts in the center of the dampers, the slight bleed-through should eliminate the need for a bypass in most systems.

If your system includes a heat pump or air conditioner, a wise precaution is to install an evaporator-



Deflated, a FlexDamper lies flat around the inside periphery of the duct (top photo). When it inflates (second photo), it seals the duct. For complete sealing, a triangular foam insert fills the center.

A typical Airzone installation (diagram) consists of two or more thermostats (regular or programmable—one for each zone), the control panel containing all the electric or electronic circuitry (electronic controls are used with heat pumps or more complex installations), and the panel that holds the solenoid valves (one for each zone), with the air-pump box beside it. Plastic tubing connects air pump to solenoids and solenoids to FlexDampers. Wiring from thermostats to the control panel is 24VAC. FlexDampers come in round and rectangular shapes to fit 5- to 14-inch ducts. Custom sizes are also available.

coil temperature-limit switch. This optional device keeps the evaporator coil from freezing: It opens all dampers and turns off the compressor any time the coil temperature drops too low.

Installing FlexDampers can be a cramped, dusty job, but compared with installing conventional dampers, it's a breeze. I installed two large FlexDampers by cutting an access hole in my furnace's supply plenum and inserting the sleeves into the ducts from there. I used, and strongly recommend, the optional plenum access door Enerzone sells. With it, you cut a hole in the plenum to match the size of the door frame (it comes in several sizes), then install the door. Once that's done you can easily get into the supply plenum without worrying about raw metal edges.

I got by with two FlexDampers because my ducting starts as trunk lines (large ducts from which smaller ducts branch). And I did not zone my entire house. If installing the dampers from the plenum won't do the job, you can install them from the outlet end of the duct by removing the register. Indeed, you can install a Flex-Damper anywhere along a duct.

Once the FlexDampers are in place, you run tubing from them to the solenoid valves, one line for each zone. Then you connect the thermostat wiring to the control panel.

I've had my present condensing oil furnace only two years, so I don't have a long record of energy use, but we did use less oil last

winter than the year before: Corrected for weather variations, it comes to 1.04 gallons per degree day this year compared with 1.19 gallons per degree day last year (though I can't be sure the difference was all due to the dampers).

The biggest benefit has been comfort: Last winter we could go into our north-facing room, turn up the thermostat, and within a few minutes the room would be toasty warm. And we didn't have to overheat the rest of the house. This summer, the air conditioner cooled the room just as quickly.

Equipment for a typical Airzone system (eight dampers) costs around \$600. With professional installation you should expect to pay \$1,000 to \$2,000, according to Tartaglino. Enerzone Systems Corp., 2660 Freewood, Dallas, Texas 75220.

PS

Electronic dogs bark at stealthy movements. Synthesized voices shout commands and warnings. Hidden transmitters exchange digitally coded messages at various frequencies to avoid detection and blockage. Watch out, burglars. New technology is now on guard.



SCOTT POLLACK

"Get within sixty feet of it, and it barks its head off," says Jack Krisel, engineering manager at Heath Co. "But you don't have to walk this dog, take it to the vet, or feed it." I'm holding it in my hands. It's not alive, definitely not cute, and, at the moment, not ferocious. "You might say it's a new breed," says Krisel, laughing. It's a new breed of all-electronic burglar alarms that use technology to protect your home.

According to the FBI, your chances of being robbed are a staggering one in four over the next 10 years. Lock the doors? Bar the windows? You could, but more than 60 percent of the burglars go through locked entries, and a skilled thief checks out more than 1,000 dwellings a week. But all is not lost.

Now microprocessors, voice synthesizers, digital encryption, radio communications, and self-testing schemes are on guard. They are part of elaborate high-tech security systems that not only check for thieves, but check themselves for accuracy too. The new technology has made wired and wireless systems incredibly more reliable, and has even created entirely new all-in-one alarm systems...like Heath's barking dog.

Hounding thieves

"We wanted a simple-to-install system," says Heath's Krisel, "but we wanted something that would be a real deterrent." To do both, Heath designed its Barking Dog alarm.

To spot an intruder, the alarm uses an infrared detector. Like other infrared devices, it uses a lens to break its viewing area into small segments called zones. The source of heat must *move* from one zone to the next before it sounds an alert. "That keeps it from going off if your home heating system comes on," says Krisel. But because the Heath alarm might be used outdoors, its logic circuit is fussier than usual. "It carefully checks the amount of time it takes the source of heat to move across the zones," says Krisel. "That prevents false alarms caused by falling leaves or small slow-moving animals." And the bark?

"We knew dogs were a strong deterrent to thieves," says Krisel. "So we recorded a bark." To put the bark in the security system, the recording was digitally synthesized—each sound converted into a digital number—and stored in a memory chip. When the alarm detects an intruder, the digital woofs are reassembled into sounds and played through the unit's speaker. "Choosing the right bark was the hard part," says Krisel. "We listened to all kinds of breeds." What did Heath choose? "It's a mutt from the local pound."

While the Heath system is clever, it's limited to checking only *one* area. To establish whole-house protection there are *systems*, and technology has made major changes in these too.

"Security on."

The voice I hear is clear, distinct, and coming from a book-size console on my desk. "We use digital synthesis

too," says Tom Burgmann, manager of research, development, and engineering for Dicon Systems, Ltd. "But we use it to store a human voice that guides you through installation and operation."

The Dicon 9000 is a wireless home security system. Like others from companies such as AT&T, Black & Decker, Heath, Honeywell, Schlage, Tandy, and Universal Security Instruments, it uses remote battery-powered modules attached to sensors for protection. When a sensor on a door or a window detects an entry, the module transmits an alert to the receiver console.

The idea is terrific: A module and sensor can be easily added anywhere because there are no wires to connect them to the console, a feature that makes it easy for homeowners to install themselves. However, earlier designs have had two major drawbacks: "Electrical noise could cause a false alarm or block a transmission, so a true alarm is missed," says Burgmann. "And you had to remember to check the sensor batteries routinely." Now both reliability troubles seem to be solved.

"To prevent interference problems, our system uses FM transmission," explains Burgmann. "Earlier modules used AM." Like an AM table radio, earlier systems were susceptible to electrical noise created by household motors, passing cars, or even thunderstorms. "FM transmission is inherently quieter," says Burgmann. "The receiver locks on to the signal."

And if the battery gets weak? Every hour, each sensor module sends what the engineers call supervision signals to the central console. "If the status of the module is bad [for instance, a low battery] or if a module doesn't check in at all," says Burgmann, "the console knows something is wrong, and it tells you about it."

"Trouble on module three," comes the voice from the box in front of me.

"That's one of its stored messages," says Burgmann.

Panic buttons

A microprocessor determines the type of emergency, depending on which module sends the alarm. "Fire, burglary, and medical panic buttons send different digital codes to the system," says Burgmann. And once you enter your list of emergency phone numbers, the smart microprocessor knows *who* to call on the phone. "In a fire, it might call the fire department first, the police, and then a neighbor," says Burgmann. "The order and numbers could change if the system detects a break-in." When a call is made, the

synthetic voice describes the type of emergency, using one of its other stored messages.

Traditional burglar alarms check the electrical continuity of sensors such as magnetic reed switches or plunger switches that are connected via wire. If a switch opens—because a thief opens a window—an alarm sounds. "But you never knew which sensor tripped the alarm," says Ron Goldman, control product manager at Ademco. "It could

[\[Continued on page 102\]](#)



**"If we
can make a
digital dog
now, maybe
we can take a
real bite out
of crime in
the future"**

Radon Zapper

A team of Harvard scientists found that the combination of a fan and a positive-ion generator could dramatically reduce concentrations of cancer-causing radon decay products. Now there's a machine based on their research. If your house has too much radon, this is one way you may be able to reduce your risk—without tearing up your basement.

By DR. DADE W. MOELLER

Dr. Dade W. Moeller is Professor of Engineering in Environmental Health at the Harvard School of Public Health in Boston, where he is also Associate Dean of Continuing Education. Prior to joining the Harvard faculty, Moeller worked for 18 years as an environmental engineer in the U.S. Public Health Service. He is a member of the National Council on Radiation Protection and Measurement, an advisory group chartered by the federal government, and he chaired an NCRPM committee that has just completed a four-year study of radon control methods inside houses. The committee's report was published in September.

It weighs 19 pounds, stands a foot high, and measures 16 inches in diameter. To install it all you do is plug it in. Yet this unassuming machine is a potent new weapon in the war against radon.

Called the No-Rad, it grew out of research done at the Harvard School of Public Health by Dr. Edward Maher, Dr. Stephen Rudnick, and myself. Interestingly, it does not reduce the concentration of radon. But it greatly reduces the health hazard posed by radon. Indeed, we found that simply using a fan to circulate the air in a house can help do that.

The EPA attributes 5,000 to 20,000 lung-cancer deaths each year to radon, a radioactive gas that is produced through the successive decay of uranium. But it is not the radon itself that harms the lungs. Though you may inhale the gas, it is inert and does not interact with body tissues. And its half-life is 3.8 days, so chances are you'll exhale it before it decays.

When the radon decays, however, solid radioactive particles are formed—polonium, bismuth, and lead—and these have half-lives ranging from just a few seconds to 30 minutes. Because they are solids, they tend to lodge in the lungs, and because they have short half-lives, they tend to decay there. At least 95 percent of the radiation dose to the lungs attributable to radon comes from these solids.

Most methods for dealing with ra-

don in houses are aimed at diluting its concentration, or preventing its entry in the first place. In houses with serious radon problems, radon-mitigation contractors may jackhammer the basement floor to install pipes below ["Radon Revisited," Sept. '87]. These are run to the outside and a fan is installed on the outlet to depressurize the area beneath the basement constantly. It's a messy—and often costly—project.

Clearing the air

Ed Maher, a U.S. Air Force lieutenant colonel who now directs a worldwide radon testing program for the Air Force, came to the Harvard School of Public Health for doctoral studies in 1982. Knowing that the health hazard of radon is really from the solid decay products, Maher became intrigued with the notion of using air treatment to reduce the risk. Steve Rudnick, an aerosol physicist, and I were his faculty advisers.

We first tried the obvious: filtration (passing the radon-contaminated air through a highly efficient filter) and electrostatic precipitation (a process in which the air passes between two highly charged plates).

We tested the devices in a 2,750-cubic-foot chamber (about the size of three rooms in a house) into which we can pipe radon, which we get from a chunk of radium. A fan blows air over the radium, and the air is distributed through perforated PVC pipes along the floor of the chamber. That mimics its diffusion into the basement of a house. Sensitive instruments measure the concentrations of radon and its decay products.

As expected, both the filter and the electrostatic precipitator removed a high percentage of the airborne radon decay products. But when we analyzed the data we found a major surprise: The air-cleaning devices could actually *increase* the radiation dose to people breathing the treated air.

We traced this paradox to—of all things—too little dust in the air. Here's why: When radon decays, it emits an alpha particle, which fires through the electron cloud of the radon atom, carrying electrons with it. That leaves the residual atom—the decay product—highly positively charged. Thus it immediately tends to attach to dust in the air.

When you use an effective filter or electrostatic precipitator, not only do you remove many of the radon decay products, you also remove most of the dust. But the radon gas is still present and still producing decay products—which have far fewer dust particles to which to attach.

TWO-STAGE FILTER
(REMOVABLE FOR CLEANING)

AIR
IONIZER

AIR IN

FAN

AIR OUT

IONIZATION
SWITCH

FAN-SPEED
CONTROL

JANA BRENNING



The No-Rad fan/ion generator emits positive ions, which repel the positively charged radon decay products, pushing them toward room surfaces where they adhere. The fan enhances the process. No-Rad's filter removes dust, smoke, bacteria, and pollen from the air, and reduces the amount of dirt that the ionizers would otherwise cause to be deposited on surfaces. To ensure a balance of ions in the air, the No-Rad also has a negative-ion generator.

And that's the problem: Atom for atom, an unattached radon decay product produces 3 to 40 times the radiation dose to the lungs as does an identical atom attached to dust. The unattached particles are chemically far more reactive. Also, a partial coating of dust keeps the attached particles from intimate contact with lung tissue.

Our data showed that the net result of air-cleaning devices can lead to as much as a doubling of the radiation dose to the lungs. It was a startling finding.

Charging ahead

Next we considered ways to capitalize on the charge carried by the radon decay products. If they could be brought into contact with room surfaces, we hypothesized, they might stick because of their charge. The radiation these particles emit has low penetrating power, so unless they decay in your lungs, they pose little hazard.

First we put an ordinary box fan in

our test chamber and turned on the radon machine. Instruments showed that the fan removed 50 to 60 percent of the decay products from the air. More important, when we analyzed the data, we found that the fan removed both attached and unattached radon decay products and reduced the dose to the lungs by an amount comparable to the reduction in the airborne concentration of the decay products.

Buoyed by this success, we tried enhancing the charge with negative- and positive-ion generators. These ionize the oxygen and nitrogen atoms in the air. We reasoned that the charged air would repel the charged decay products and expedite their movement toward room surfaces.

We tested specially prepared ion generators in the laboratory chamber and found both to be effective, but not equally so. The negative-ion generator removed 65 to 70 percent of the radon decay products; the positive-ion generator removed 80 to 85 percent. The reason, we suppose, is that the negative-ion generator has to overwhelm the positive charge on the decay products before it can have the desired effect.

Finally, we tested combined approaches and came up with a winner: a ceiling fan plus a positive-ion generator. This combination removed 90 to 95 percent of the radon decay products in our laboratory tests. Analysis showed it would reduce the radiation

dose to the lungs by 68 to 87 percent.

Since our tests were published, scientists in Canada, Finland, Denmark, and the United Kingdom have confirmed our results.

In 1986, with the help of the university, we got a patent on the concept, and eventually licensed Ion Systems to develop a commercial product. The result is the No-Rad machine, a three-speed hassock fan that contains positive-ion generators. (It also contains a negative-ion generator, but that was not our idea. Scott Gehlke, president of Ion Systems, insisted on including it because of the folklore that negative ions make you happy and positive ions depress you.)

We tested commercial models of the No-Rad in our laboratory and got dramatic results (see graph). We also tested the machine in houses in Massachusetts and Connecticut. There we got decay-product removals in the range of 75 to 90 percent. Tests by the EPA are pending.

Now we're testing other configurations of these components, including two that would place everything between the studs within a wall. Preliminary tests show these schemes to be effective.

What to do

If your house has high concentrations of radon, you should consult recognized experts. But the vast major-

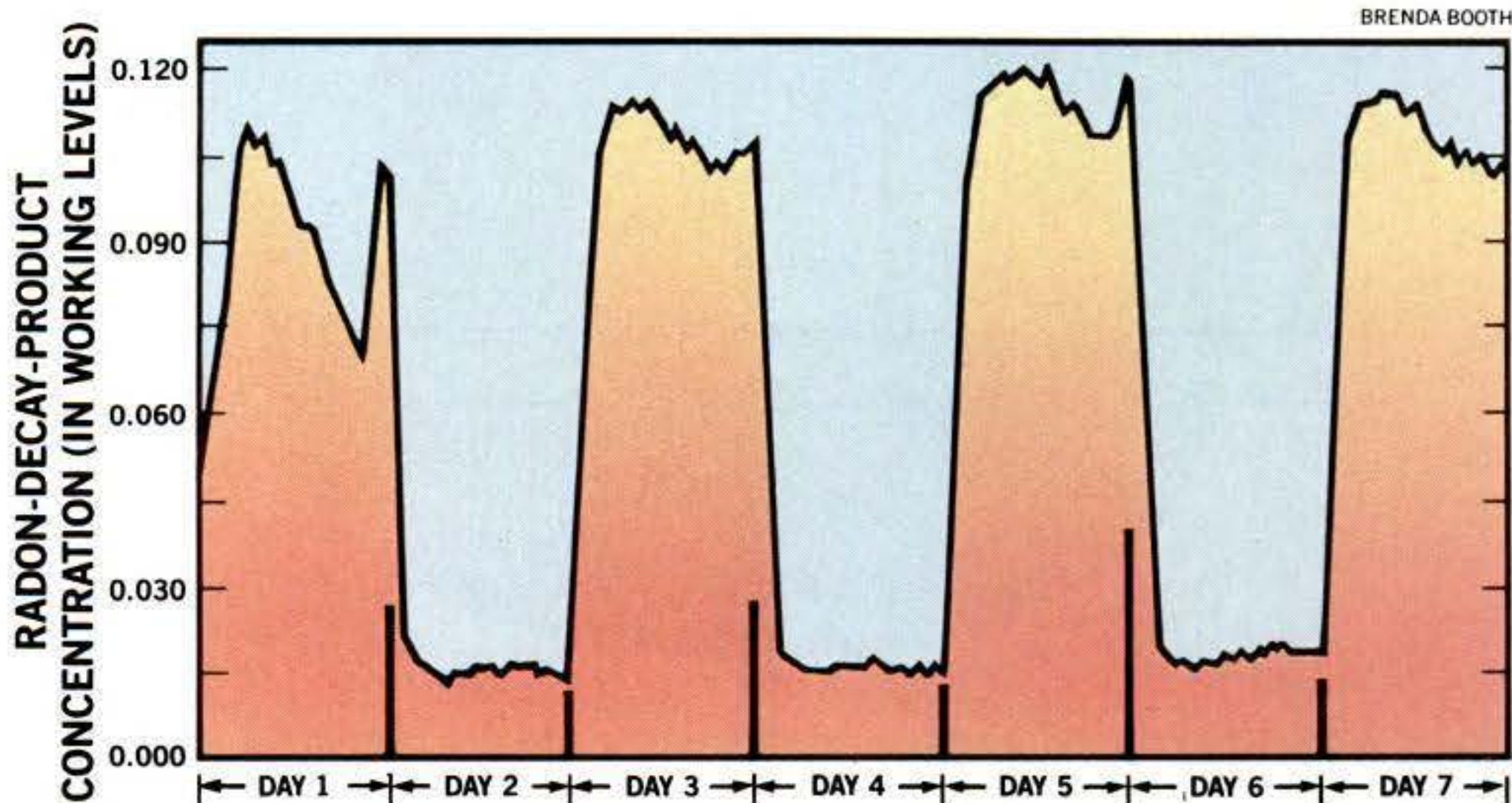
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ity of houses with radon problems have just a little too much—and need just a little correction.

The EPA recommends that the radon concentrations in houses be kept below four picocuries of radon per liter of air. If you monitor your house and find that it has up to double that amount, then simple circulation of the air will probably provide adequate protection. If you have ceiling fans, just turn them on slow speed and let them run. If you have a forced-air heating or cooling system, you can rig it so the air handler runs continuously instead

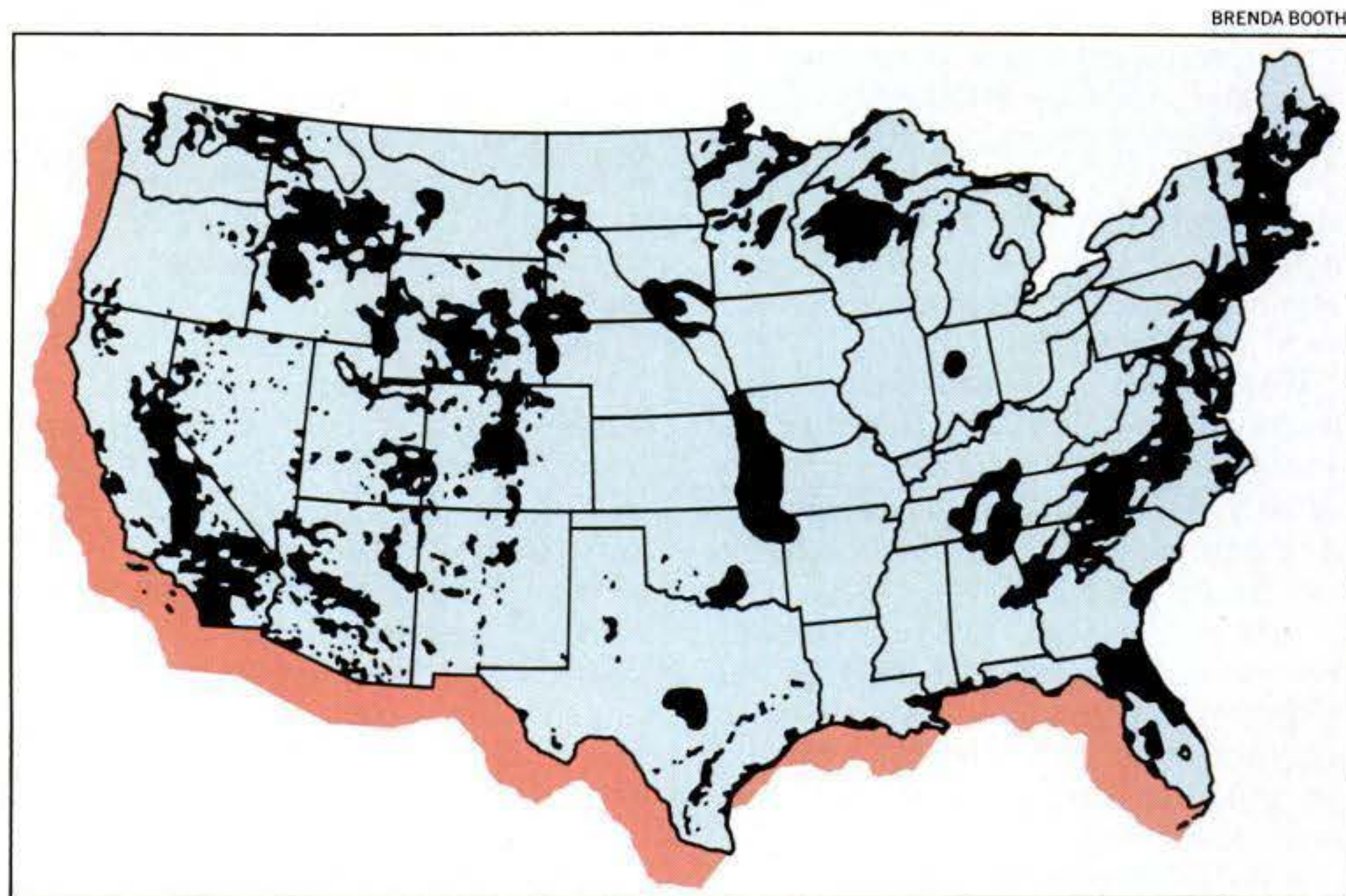
of cycling. Almost any fan will help.

If your house has radon concentrations of 5 to 10 times the recommended maximum, additional control measures are necessary. We think the No-Rad machine is the simplest solution. Ion Systems claims that one machine will cover a 300-square-foot area. Our tests suggest that is conservative: It should serve a larger area if there is good airflow. The machine (list price \$350) can be used independently or as supplement to other remedial measures. Ion Systems, Inc., 2546 10th St., Berkeley, Calif. 94710. **P 5**



A No-Rad machine underwent seven days of testing in a 2,750-cubic-foot chamber at the Harvard School of Public Health. The machine was operated on alternate days, reducing the concentration of radon decay products dramatically each time, as the chart shows. Measurements are in Working Levels

(WL), a standard measure of radon decay products. The EPA's recommendation for maximum radon in houses is stated as a measure of the radon gas itself, in picocuries per liter of air (pCi/L). A radon-decay-product concentration of 0.02 WL is roughly equal to four pCi/L, the EPA's "action level."



Houses with high radon levels have been found in all 50 states, but the underlying geology of an area is one clue as to where such houses are most likely to be located. This map indicates areas known to have high levels of uranium

or radium. When uranium undergoes radioactive decay, it becomes radium, which, in turn, decays to form radon gas. Geologic data can only suggest potential problems; the only way to know if a house has too much radon is to test.

GETTING THE GAS

While Ion Systems' No-Rad machine removes the radon decay products from the air, another new machine removes the radon gas itself. It's called the RAdsorb-222, and it uses charcoal to adsorb the gas. Like the No-Rad, it originated in the Boston area. Indeed, Dr. Stephen Rudnick of the Harvard School of Public Health participated in the research for both.

The prime mover behind the RAdsorb, however, is Richard Abrams, a chemical engineer who formerly worked for a company that installed charcoal filters to capture radioactive gases emitted from nuclear plants. When the radon scare hit the headlines a few years ago, Abrams got interested. "Radon is in the same family of gases as those I was dealing with," he says. "And charcoal is known to be effective in adsorbing it as well."

But to use charcoal to remove radon from buildings would require that it be purged frequently of its radon load. Earlier experimenters had tried blowing heated air over charcoal to purge it of radon. That worked well, but wasted a lot of energy.

Abrams' concept, patented in 1987, called for using outside air at ambient temperatures. He explains: "When it's cold, the radon atoms slow down and tend to stick to the carbon particles more readily. Thus to purge the charcoal bed with cold air you have to increase the flow rate." He came up with a control system that varies the airflow rate inversely with air temperature.

He also came up with the idea of using two charcoal beds: A blower draws radon-laden air from the house into one bed of charcoal where it is stripped of its radon, then sent back into the house. Meanwhile, a second fan blows outside air through the charcoal in the other bed to pick up the radon, then channels that contaminated air back outside. In the production RAdsorb, the charcoal is in a cylinder divided into two parts. Every 15 minutes the cylinder rotates so that the side that has been in the house airstream is moved to the outside airstream.

Abrams first made a one-quarter-scale model that was successfully tested at the University of Pittsburgh. Next he fabricated a full-size prototype and took it to a house in New Hampshire with a radon problem. For 14 hours prior to testing, a continuous radon monitor recorded readings of 11 picocuries of radon per liter of air. (The EPA's recommended maximum is four pCi/L.) Then Abrams turned on the RAdsorb machine. Within three hours the radon dropped to 2.4 pCi/L.

Now, the EPA is testing a RAdsorb in a house in Nashville, Tenn., where radon readings from 6 to 66 pCi/L have been measured. Preliminary results show the RAdsorb has dropped it to below one pCi/L.

The smaller the basement, the higher the radon concentration the RAdsorb can handle. In a typical basement, say 45 by 22 by 7½ feet, it should reduce radon concentrations from 20 pCi/L down to four pCi/L.

The RAdsorb is 26 by 28 by 64 inches high and weighs 400 pounds. It must be installed by a radon-mitigation contractor. Installed, the RAdsorb averages \$3,000. RAD Systems, Inc., 21 E. Main St., Westboro, Mass. 01581.—*V. E. Gilmore*



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*J.D. Power and Associates 1989 Initial Quality Survey covering November and December, 1988. Based upon owner-reported problems during the first 90 days of ownership.



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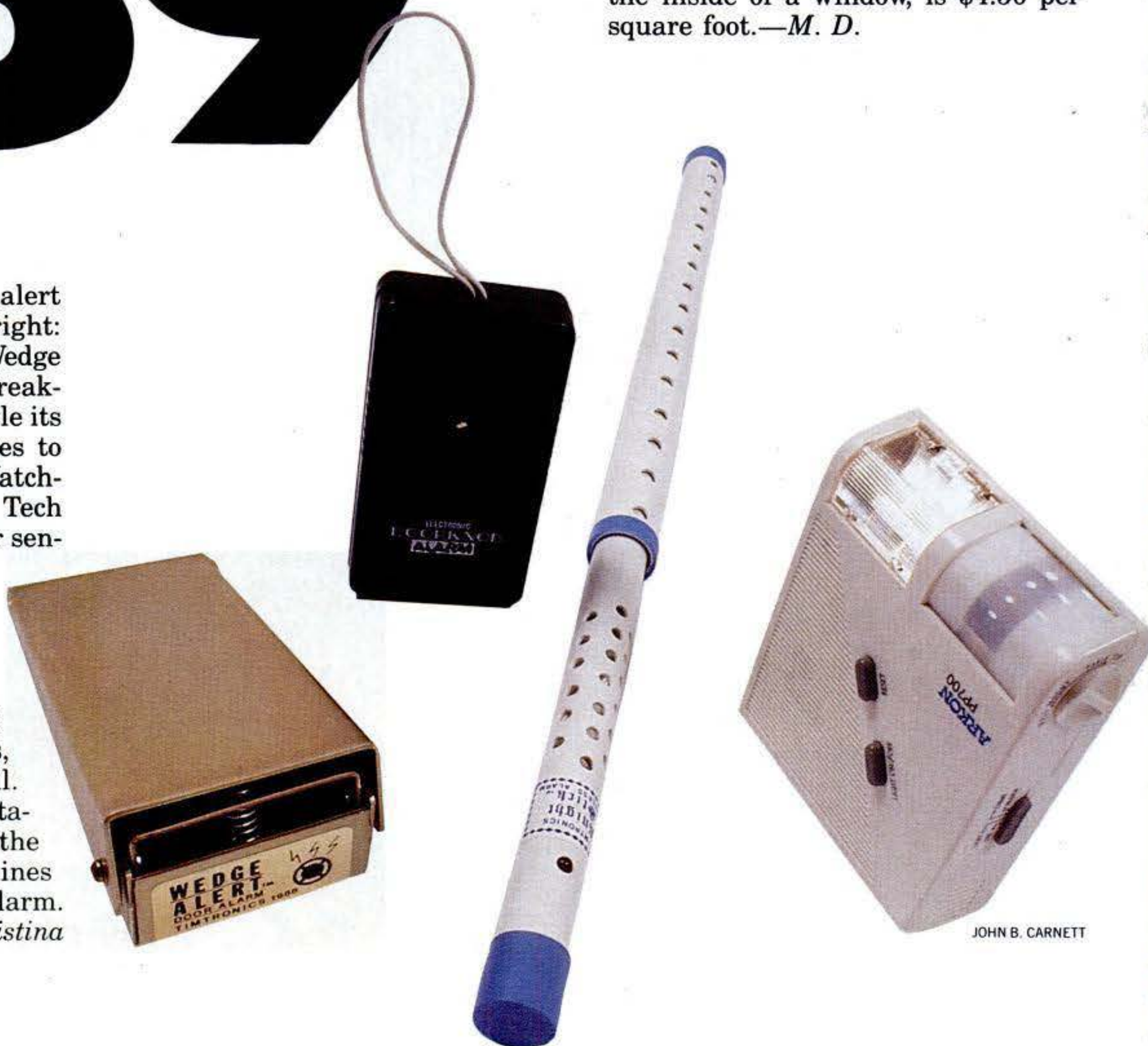
SECURITY 189

ANTI-SHATTER FILM

Insul*film can discourage "smash and grab" burglaries and prevent dangerous shards from windows broken by accident or storm. Impregnated with chemical and metal coatings, the clear polyester two- or four-mil film also screens out up to 99 percent of fabric-fading ultraviolet rays, says the maker, Gila River Products. The average price, installed on the inside of a window, is \$4.50 per square foot.—*M. D.*

PORTABLE SENTRIES

These four new alarms can alert you to intruders. Left to right: Timtronics Technology's Wedge Alert warns you of attempted break-ins with an 85-decibel alarm while its sponge-rubber footing compresses to stop the door. Cost: \$30. The Watchdog Doorknob Alarm by Travel Tech International can be adjusted for sensitivity and works when hung on the metal knob of a non-metal door. Touch the outside knob, and the \$15 alarm growls an 85-decibel warning. Sliding doors can be guarded by the \$24 Knight Stick, also by Timtronics, which fits between door and wall. Aim Arkon Resources' PP700 Porta-Guard at your entry way, and the \$50 device detects motion and shines a light, chimes, or sounds the alarm. Range: 15 feet.—*Mariette DiChristina*

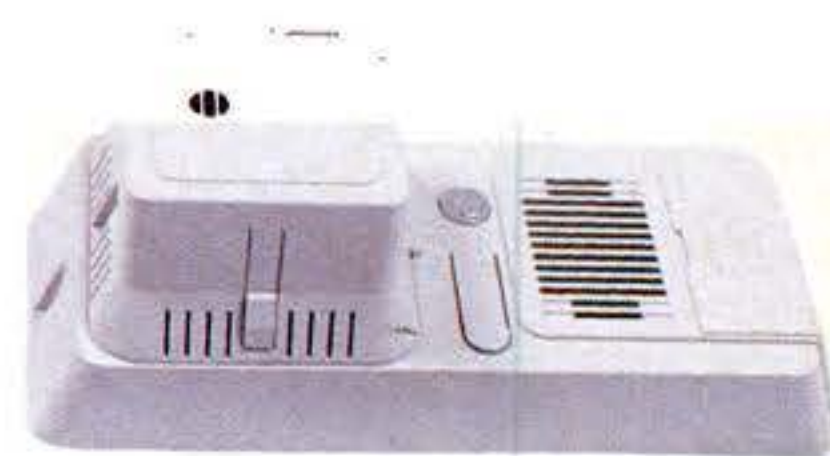


JOHN B. CARNETT

ACRYLIC LIGHTING

Low-voltage lighting not only illuminates dark areas around your house for added security, it also lights walkways and steps to provide you with more safety. Lumiere's Tahoe line of 12-volt halogen

lights has crowns tooled from solid rods of ultraviolet-stabilized acrylic. They can provide an interesting visual effect and can shed light in a variety of directions and patterns.—*Timothy O. Bakke*



JOHN B. CARNETT

SUPER SNIFFERS

Earli-Gard Safety Products' VocAlert smoke detector (top) blasts a 10-second 85-decibel alarm when it senses smoke—and then calmly *tells* you how to escape with phrases you've previously selected from its 100-word vocabulary. Each \$100 battery-powered unit covers a 1,200-square-foot area. No need to climb a step stool or chair to test First Alert's smoke detector (bottom): Just point a flashlight upward, and the battery-powered alarm beeps if it's working. A sensitive cell responds to the flashlight, but not to daylight. The \$15 detector also has manual test. Can't remember to test your detector? With Jameson Home Products' Code One 2000 Auto-Test, you don't have to. After you connect the battery, the \$17 alarm checks itself weekly and beeps six times if it's OK. Day and time can be changed by disconnecting and reconnecting the battery.—*M. D.*

Continued



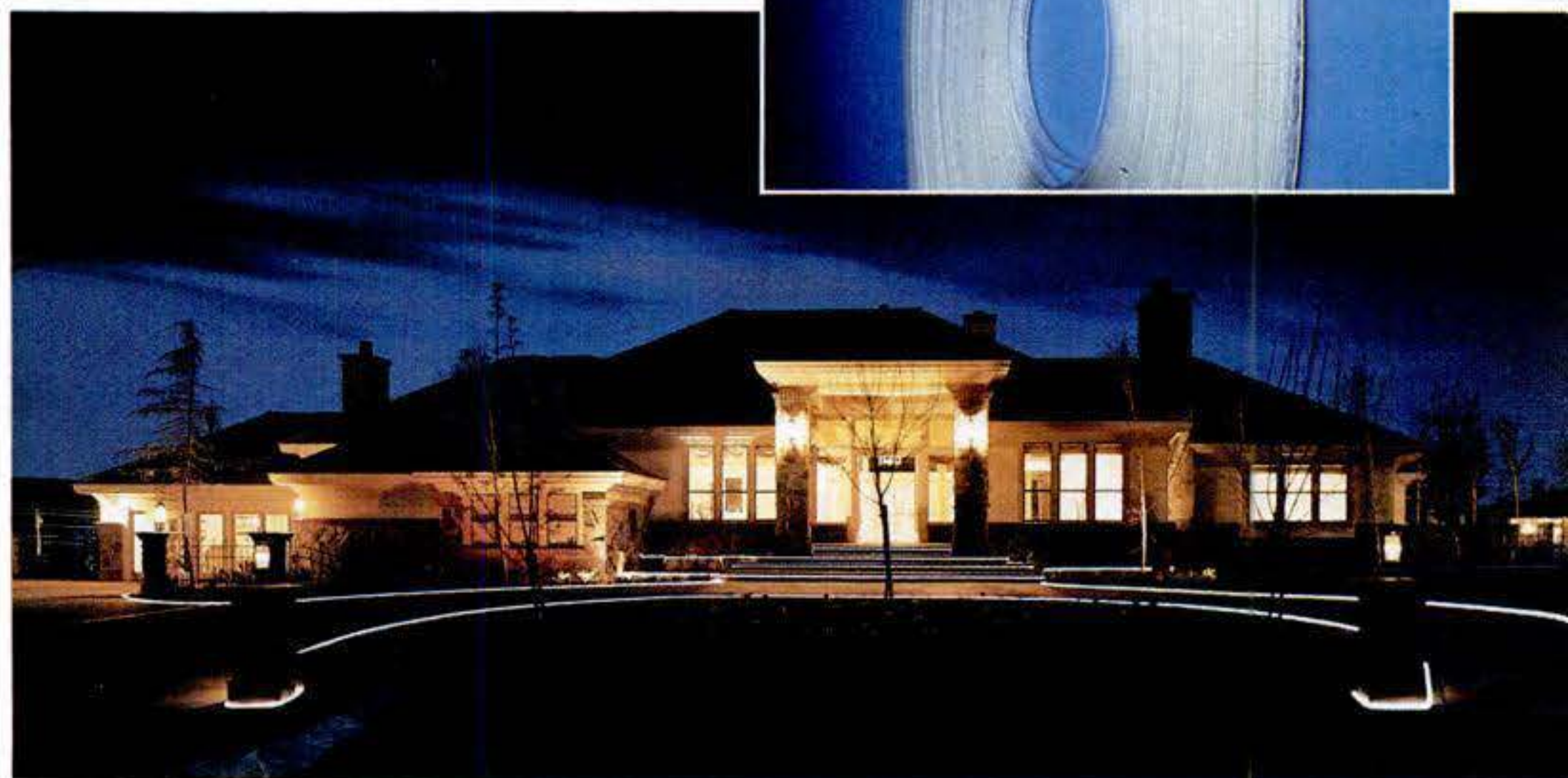
FIBER-OPTIC FUN

Fiberstars uses a fiber-optic cable and a 250-watt quartz halogen light source to light steps and walkways. The optical cable (inset) runs in a loop out of and back into the light-box source. Each box can handle two loops of 200 feet each. One box and a cable loop: \$2,200.—*T. O. B.*



ESCAPE LADDER

At 4½ inches across, the aluminum-alloy JOMY ladder looks like a drainpipe when closed. But with a quarter turn of the handle, it unfolds into a fire-escape route. A locking mechanism prevents unauthorized ground use.—*M. D.*



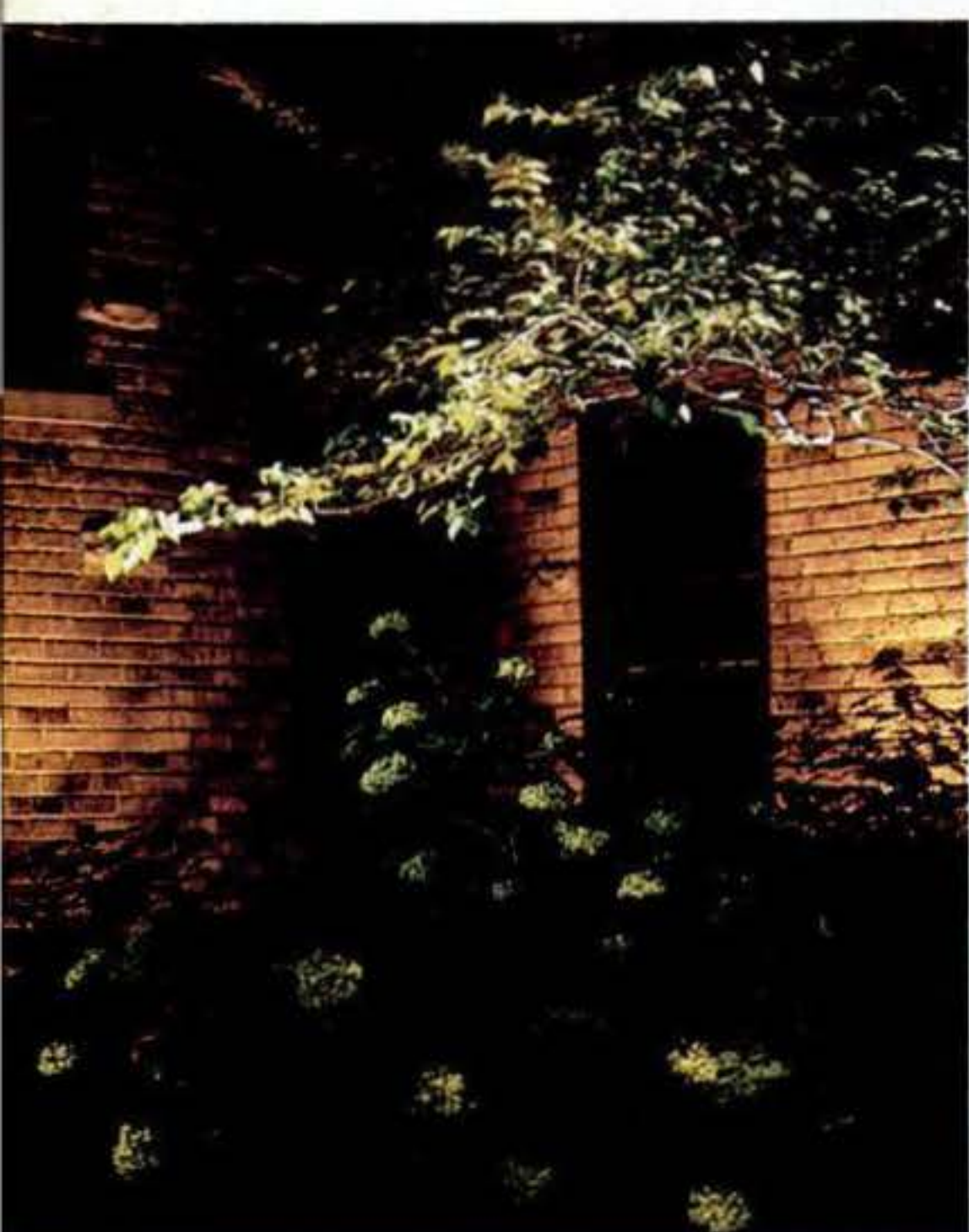


JOHN B. CARNETT



DECKED-OUT LIGHTS

Low-voltage (12-volt) outdoor lights from TerraDek (shown), or AdjustaPost, Intermatic, or Toro are made with wood trim to complement deck materials. The lights are designed to illuminate railings, steps, and other decking areas without having to use exposed wiring.—*T. O. B.*



DRESSY LIGHTS

New outdoor lighting can help prevent accidents—and jazz up your house. Toro's 12-volt lighting (top) includes floods with adjustable beam widths to brighten up dark, shadowy areas around the house, as well as accent lights. A new 24-volt system from Geisha (above and right) uses tiny tube lights to brighten steps and other areas. While most 12-volt systems are limited to five or six lights and a run of 100 feet of cable per transformer, Geisha's system uses 20 lights per transformer and can run 175 feet from the house. Price: about \$250.—*T. O. B.*



FIREMAN IN A CAN

The ceiling-mounted Cease Fire dry sprinkler (top left) douses flames around potential hot spots like electrical boxes or storage areas. The \$60 extinguisher protects 100 square feet with a halon gas and nontoxic powder mixture in a gel, and requires no recharging in its 12-year life. You need no tools to install the Flame Eater automatic sprinkler (coiled around fire helmet): Just screw its hose into your water heater's drain spigot, turn the spigot on, and hang the sprinkler's spray head above the home and water heaters. For protection against a clothes-dryer fire, you can also hook the sprinkler to your washing machine. It's \$35. FireFox is a \$250 automatic extinguisher that mounts under the range hood (above). A flame-detecting sensor triggers a chemical release to smother fire and prevent reignition. FireFox is good for 12 years without recharging.—*M. D.*



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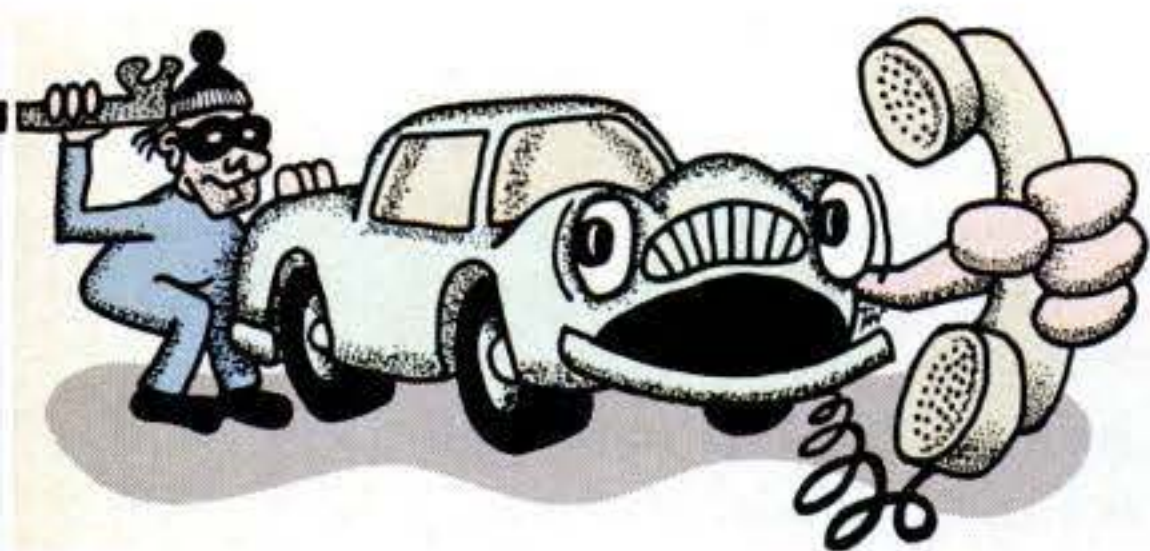


HOME SECURITY



RETROFIT SENSOR

The Heath Zenith SL-5210 decorative-lighting control has a 60-foot sensor range and can be hooked up to your existing porch or other lights. To prevent triggering by animals or leaves, the \$35 sensor takes a second "look" before turning on the light. The company makes another false-trigger-reducing sensor, which includes lights, for \$60.—M. D.

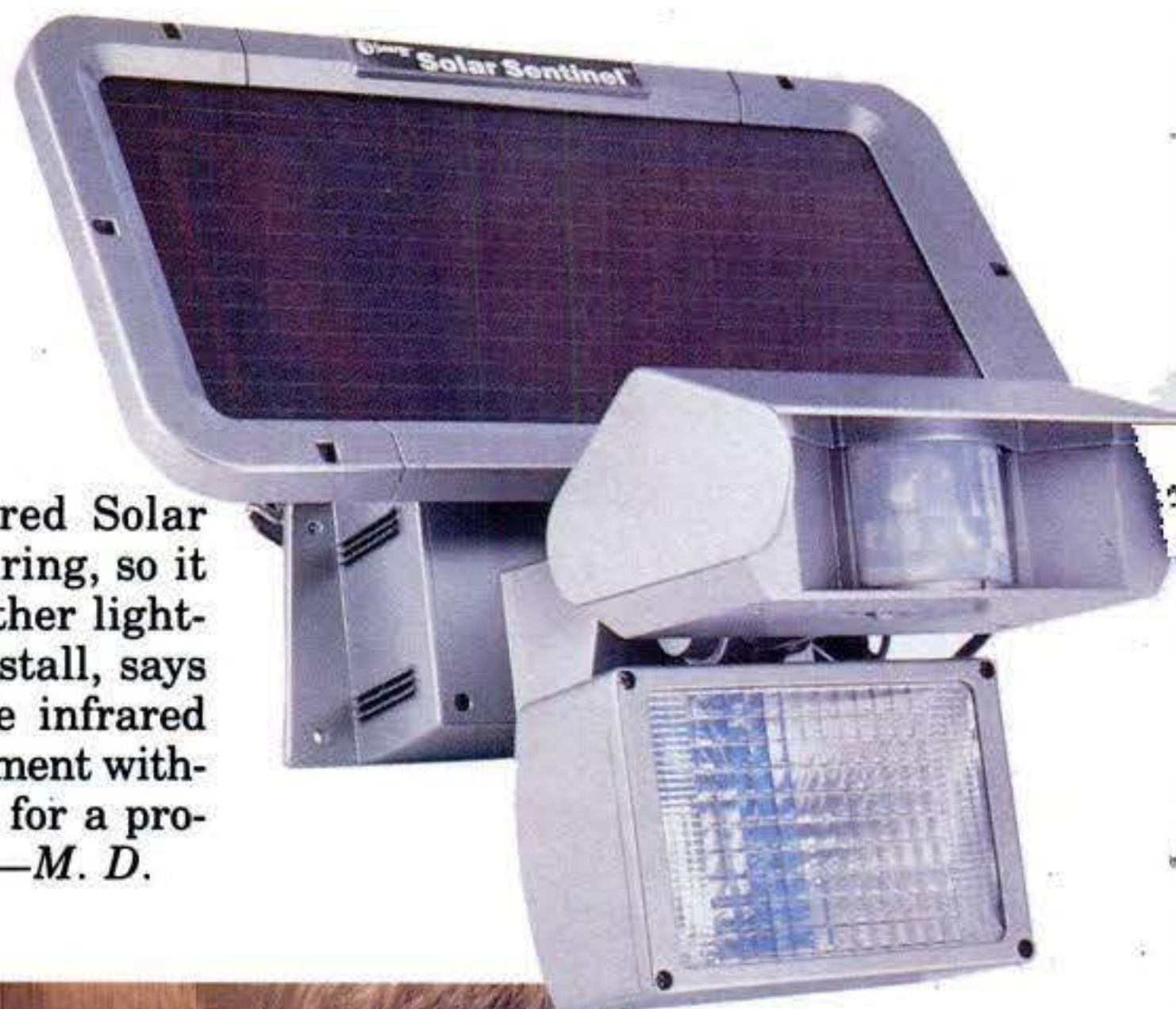


MG PHONE HOME?

Two new programmable vehicle-alarm systems don't just blare during an attempted break-in: The \$259 Audiovox Cel 200 and \$450 Alpine 8316 Communicator call you from a compatible cellular phone. The Alpine also lets you phone your car for commands—such as to close the windows or arm the system.—M. D.

SOLAR NIGHT LIGHT

The \$140 solar-powered Solar Sentinel needs no wiring, so it can be used where other lighting would be difficult to install, says Sunergy. When the passive infrared motion detector senses movement within 75 feet, the light shines for a programmed amount of time.—M. D.



LOOK MA, NO WIRES

The Nalcor wireless alarm (\$12) protects children from swallowing poisonous household chemicals, or can be mounted on a window. If a cabinet or window is opened 1/4 inch, an 85-decibel horn blares. A \$37 door-mounted unit (right) is also available.—M. D.



NO-INSTALL ALARM

Visibility discourages criminals, and that's a benefit of CarCop, says maker Kansas Microtech. Just hang the \$150 alarm on an open window, turn it on, and roll the window up. The sensitivity-adjustable device has a 105-decibel alarm.—M. D.

MANUFACTURERS LIST

Alpine Electronics, Box 2859, Torrance CA 90509; Arkon Resources, 11627 Clark St., Suite 101, Arcadia CA 91006; Audiovox Corp., 150 Marcus Blvd., Hauppauge NY 11788; Cease Fire Corp., 108 Willowbrook La., West Chester PA 19382; Earli-Gard Safety Products, 11800 28th St. N., St. Petersburg FL 33716; Fiberstars, 47456 Fremont Blvd., Fremont CA 94538; FireFox Corp., 10761 N.W. 89th Ave., Hi-

aleah Gardens FL 33016; First Alert, 780 McClure Rd., Aurora IL 60504; Geisha Corp., 151 E. Sunset Rd., Henderson NV 89015; Gila River Products, 6615 W. Boston St., Chandler AZ 85226-9498; Heath Zenith, Hilltop Rd., St. Joseph MI 49085; Intermatic Inc., Intermatic Plaza, Spring Grove IL 60081; Jameson Home Products, 2820 Thatcher Rd., Downers Grove IL 60515; JOMY Safety Ladder, Box 17578, Boulder CO 80308; Kansas Microtech, 7300 W. 110th St., Overland Park KS 66210; Lumiere De-

sign and Manufacturing, 31352 Via Colinas No. 103, Westlake Village CA 91362; Minnfac (TerraDek), 5155 E. River Rd., Minneapolis MN 55421; Nalcor, Inc., 104 Keystone Dr., Sikeston MO 63801; NDC Flame Eater, 30 Colpitts Rd., Weston MA 02193; Sunergy Inc., Box 177, Princeton NJ 08542; Timtronics Technology, Box 9692, Canoga Park CA 91309; Toro Co., 8111 Lyndale Ave. S., Minneapolis MN 55420; Travel Tech International, 8000 Raintree Circle, Culver City CA 90230

NEW LAB TEST REVEALS: SLICK 50 CAN CUT ENGINE WEAR IN HALF!

Save Gas, Save Engine with "POLY"

The following introduces one of the most fully tested and credentialed gas saving, friction reducing engine treatments ever to reach the market!

WHAT IS POLY? "Poly" is short for polytetrafluoroethylene (TFE). It is the slipperiest substance known to man. **The 1988 Guinness Book of World Records (pg. 182) says:** "The lowest coefficient of static and dynamic friction of any solid is 0.02, in the case of Polytetrafluoroethylene - equivalent to wet ice on ice. It was first manufactured in quantity by E.I. duPont in 1943, and is marketed as Teflon™."

The PetroLun Corporation, makers of Slick 50, have invented a way to permanently bind "Poly" to your engine with one treatment. All you do is add one quart of Slick 50 to your oil. By reducing engine friction, Slick 50 increases gas mileage and horsepower and it reduces engine wear, defraying costly overhauls.

Slick 50's credentials are impressive.

Just this year the premiere engine and lubricant testing lab in the U.S. tested Slick 50. This EPA approved lab conducted a strictly controlled experiment using industry standard ASTM procedures. They found that Slick 50 can dramatically reduce engine wear **by 52% under average conditions and up to 57% under maximum wear conditions.** We know of no other Poly treatment on the market that has passed a wear reduction test conducted by an EPA approved lab using nationally accepted ASTM procedures. Watch out for those treatments that cannot back up their claims with such solid evidence.

"Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicate that it will improve gas mileage by about two or three miles per gallon...Slick 50 does exactly what PetroLun claims it does." Consumers Digest, (March/April 1982, p. 35)

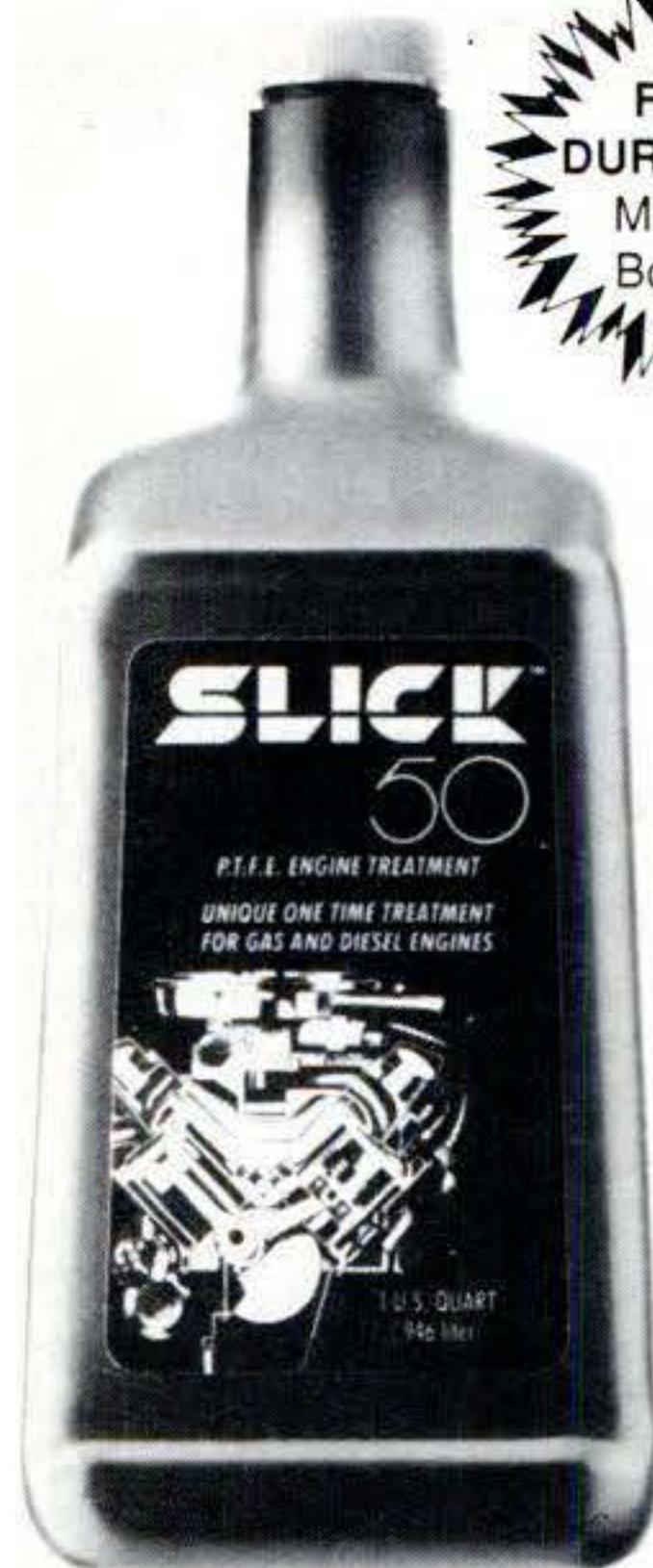
Researchers at a **nationally respected research laboratory**, after applying a powerful ultrasonic cleaning process to a Slick 50 treated engine part, were surprised at its permanence. They stated, "We actually expected the PetroLun Slick 50 "Poly" resin coating to also be removed, but later found it was still there."

The Federal Aviation Administration has fully accepted a similar product - Slick 50 Aircraft Treatment (F.A.R. #33.49).

TUV, a German testing laboratory with credentials every bit as prestigious as our Underwriters Laboratories, tested Slick 50 in 1986. They found substantial increases in both gas mileage and horsepower.

A test done at the **San Diego State University** revealed that, "Slick 50 does increase horsepower and decreases fuel consumption in tests done at the university." The **Space Shuttle Columbia** uses the chemical "Poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

Perhaps the most dramatic of all is a torture test overseen by the Automotive



Services Council for Pennsylvania. This test was shown on television station WTVE. Three cars with between 75,000 and 129,000 miles on them, were treated with Slick 50. Six months later the oil was drained from each vehicle and the cars were driven without the oil plugs for about half an hour. The water temperature never rose and the engines sustained no apparent damage.

How do you give an engine a "Poly" treatment? Very simply! Change oil and filter and substitute one quart of Slick 50 for the last quart of oil. (Add two quarts for engines with oil capacities of seven quarts or more.)

Slick 50 gives a permanent coating so you need to treat your engine only once, and not each time you change your oil. Slick 50 is also excellent for turbocharged engines, aluminum block engines and rotary engines.

Slick 50 will work with all petroleum based oils and synthetics compatible with petroleum based oils.

What are the benefits of Slick 50? Since there are many factors that influence an engine including the type of driving, temperature, engine condition, oil change intervals, etc., the actual benefits in percentages will vary. However, by reducing friction, Slick 50 does all of the following: Slick 50 **increases gas mileage.** Slick 50 **increases horsepower** - small economy cars and large RV's really need this! Slick 50 **makes for easier starting** (important in cold weather.) Slick 50 **reduces operating temperatures**, thus increasing the lubrication of your oil and the life of your engine. Since lubricating lead is being removed from gas, and unleaded gas is poor in lubricating qualities, **this extra lubrication of Slick 50 on valve systems and guides is a real bonus.**

Last, but not least, the drastic reduction in engine wear can delay costly overhauls. These can often cost well over \$1,000. Slick 50 eliminates the "lubrication starvation" that all cars experience when you first start them, before the oil has a chance to circulate. Up to 90% of engine wear can be caused by this starvation. You receive all these benefits for less than the cost of two tanks of gas (\$39.95).

Will Slick 50 harm my engine or affect my warranty? No! The base oil for Slick 50 meets, or exceeds, every manufacturer's engine warranty requirements and carries an API service classification SG-CD.

More Slick 50 products are available. These include Automatic and Manual Transmission treatments, Power Boost, Marine Engine Treatment, Motor Cycle and Small Engine Treatment, 2 Cycle Engine Treatment, Gas and Diesel Fuel Treatment and Grease. Free information sent on request.

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Guaranteed lowest price and guaranteed satisfaction. If at the time of purchase you have seen Slick 50 advertised in a current magazine at a lower price, we will beat that price by \$2.00 a quart and you will still get your free DURALT FC. If you are not satisfied with our Slick 50, within 4 months, send us a note and proof of purchase for a full refund of purchase price. This makes trying Slick 50 **RISK FREE** to you. We have been in business for 10 years and intend to keep our customers happy.

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PS 10

"Say, Smokey—"

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Belted valves

I have a 1984 Honda Civic DX with 50,000 miles on the odometer. I was driving recently on the highway when I heard a wrenching noise from the engine. When I stopped, I noticed that the water pump was leaking anti-freeze. The mechanic said that the water pump had seized, which chewed up the timing belt and bent 10 of the engine's 12 valves in the process. The repairs took two weeks and ended up costing me \$1,100. Was this job on the level?

Alan Fleck, Newark, Del.

Timing belts have not been holding up as well as auto engineers had originally hoped. Most manufacturers with belt-driven overhead-cam engines specify that the belts be changed at intervals between 40,000 and 60,000 miles. But I've seen some belts that have lasted over 100,000 miles. Some engines are designed so that the valves don't hit the pistons if the belt fails. It's likely that we'll soon see more mechanical drives and fewer belts in the future or at least much stronger belts.

Floored brakes

The Chevrolet P30 chassis underneath my motor home has front and rear disc brakes, and has gone about 10,000 miles. After driving it awhile, the brake pedal goes all the way to the floor. When I release the pedal and re-apply, the brakes feel normal. There's no sponginess or pedal-drop. The pads are not worn, I see no evidence of fluid leakage, and the master cylinder has been topped off. All the mechanics I've asked want to start changing parts without being able to give me an explanation of the problem's cause.

F. J. Doherty
Hawthorne, Calif.

The problem could be that the brake pads are retracting too far from the rotor, or perhaps there's excessive left-right movement of the calipers. These conditions would require a large amount of master cylinder travel to move the pads into operation. Another possibility is that your master cylinder has a problem that limits its fluid-charging in retraction. There is also still some chance that you have air in the system. Examine the brake pedal

linkage from the master cylinder to the pedal for excess movement.

Locked-up shift

I have a question about my 1989 Chrysler Grand Voyager with the new electronically controlled four-speed automatic transmission with the lock-up torque converter. The torque converter unlocks when the accelerator is released for a moment and then locks up again when I hit the gas. It constantly shifts when you vary the throttle. How about a manual-override switch?

Frederick A. Blandford, Hilton, N.Y.

The lock-up torque converter is the brainchild of engineers who are trying to improve mileage. The systems get their main instructions from a computer that monitors engine vacuum: Low vacuum, produced when the engine loads, unlocks them. High vacuum, generated at light load conditions, locks them up. Also, these converters are designed to work in conjunction with the emissions controls. Therefore, the annoying shift pattern is contrary to your gut feelings about how it should work. You could install a manual control, but it's illegal because officials in charge of lowering emissions don't want any changes from the car's certified configuration.

Unpowered steering

The power steering on my 1987 Buick Le Sabre is stiff when I start the car after letting it sit all night. It frees up when I move the steering wheel back and forth a couple of times. What's the problem?

Rudy Zulich
Highland Heights, Ohio

Take that car back to the dealer for warranty repairs soon. There has been a lot of trouble with that model's steering equipment. In most cases it's not dangerous, just stiff when cold, but steering is not an area in which a defect is acceptable. If the dealer tries to charge you, don't give in. The repair should be on full warranty.

Tight bolts

I was about to repack the front bearings on my 1987 Ford Thunderbird,

so I used my torque wrench to remove one of the calipers. To my surprise, it didn't work, and in the process I stripped both the bolt and tool. I tried another torque wrench, but got the same results. A mechanic told me that Ford put Loc-Tite on the bolts during assembly. He said heating the bolts before removal sometimes does the trick, but most of the time you have to buy new bolts.

Paul Bijlsma, Ceresco, Neb.

Loc-Tite is used instead of mechanical locks probably because it's cheaper. We use Loc-Tite on race cars just about everywhere. You should be cautious in applying locking chemicals because each has specific applications. Most mechanics consider the use of Loc-Tite to be a good move.

Shift grinder

The gears on my 1988 Daytona Shelby grind when I shift the transmission from first into second on cold mornings. Do you have any suggestions?

Daniel K. Rothermel, Reading, Pa.

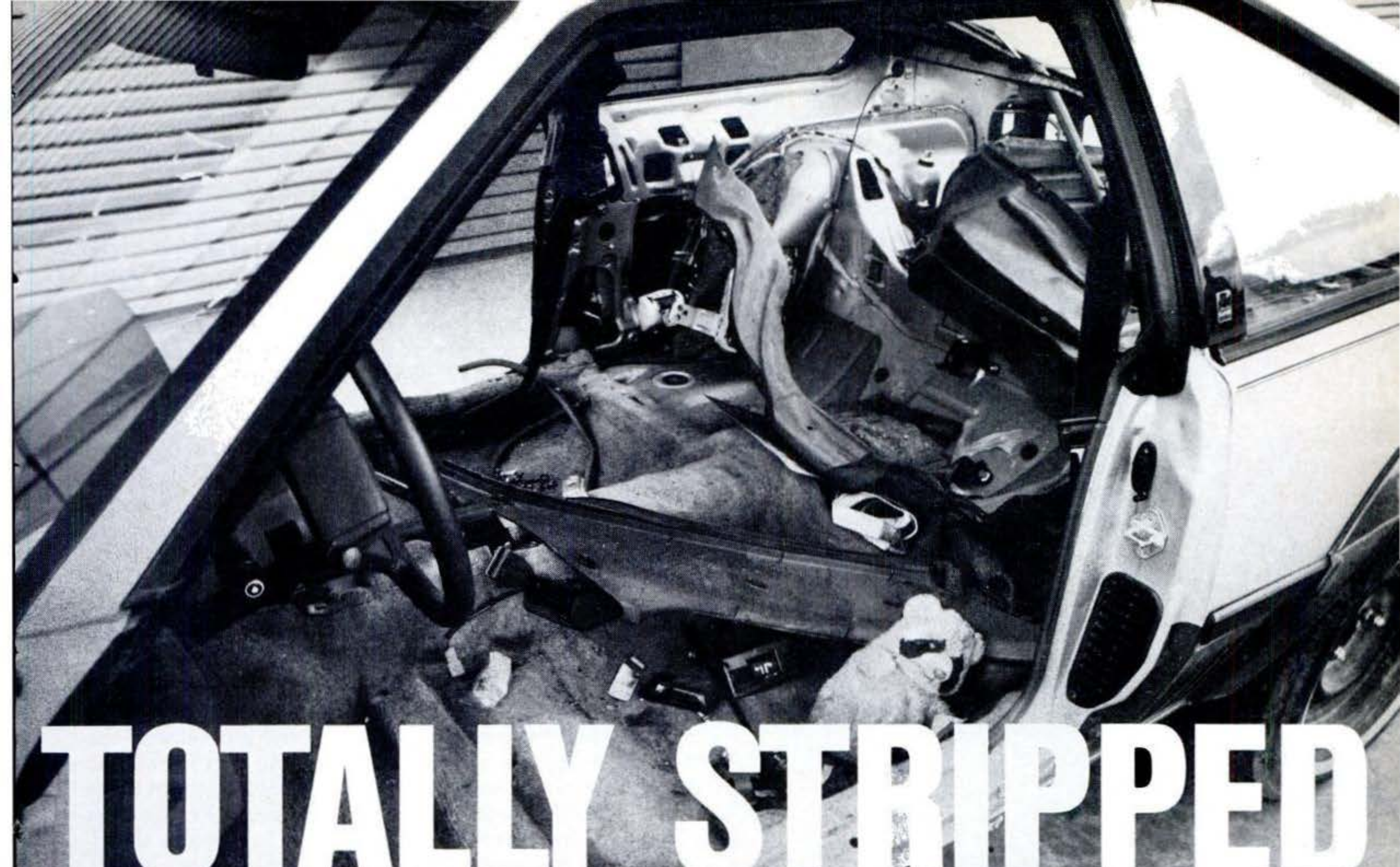
The gears will grind if the clutch-release mechanism is not working properly. Cold weather increases the thickness and drag of the transmission lubricant, making shifting hard at times. Check with Chrysler to see if using automatic transmission fluid, which is much thinner, is appropriate. If so, give it a shot. If that doesn't work, take a look at the clutch, synchronizers, linkage, and pressure plate for wear or damage.

Hot under the turbo

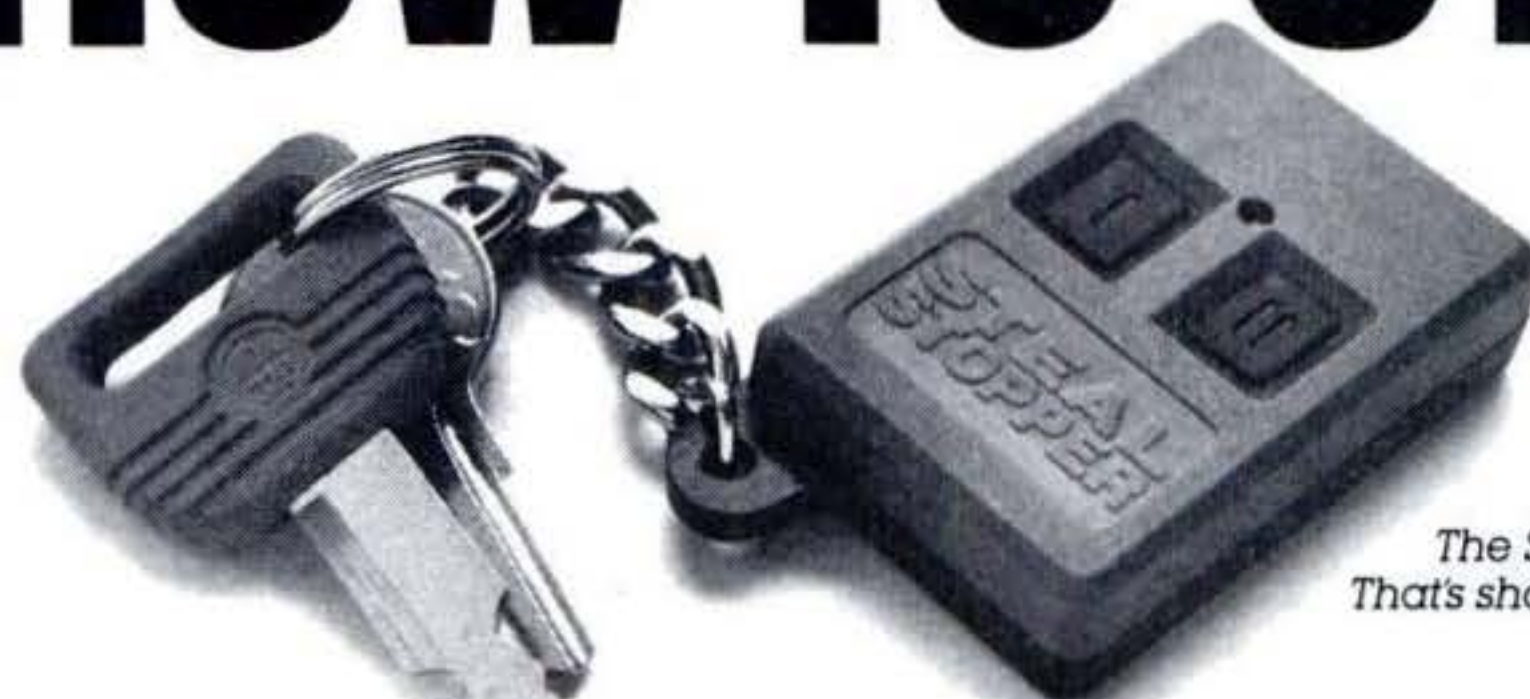
I have a 1986 Ford Thunderbird with a turbocharged 2.3-liter engine. The exhaust manifold and turbo housing glow orange after only three miles of driving. The dealer says nothing is wrong with it.

Charles L. Druce
Chula Vista, Calif.

The exhaust system on a turbcharged car under full boost will often turn yellow from heat. However, most turbocharged cars hardly ever get to full-boost pressure. But in the hands of a hot rodder, this waste heat can damage some parts that may be placed too close to the exhaust system.



TOTALLY STRIPPED AND HOW TO STOP IT



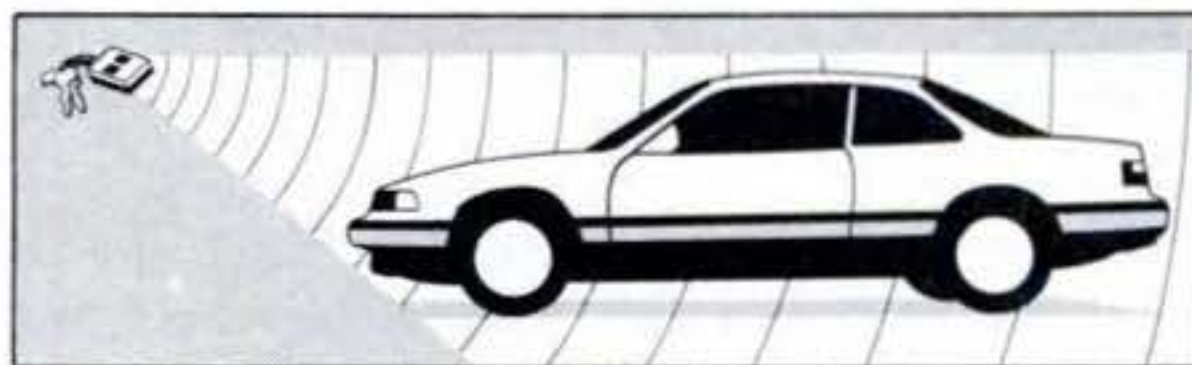
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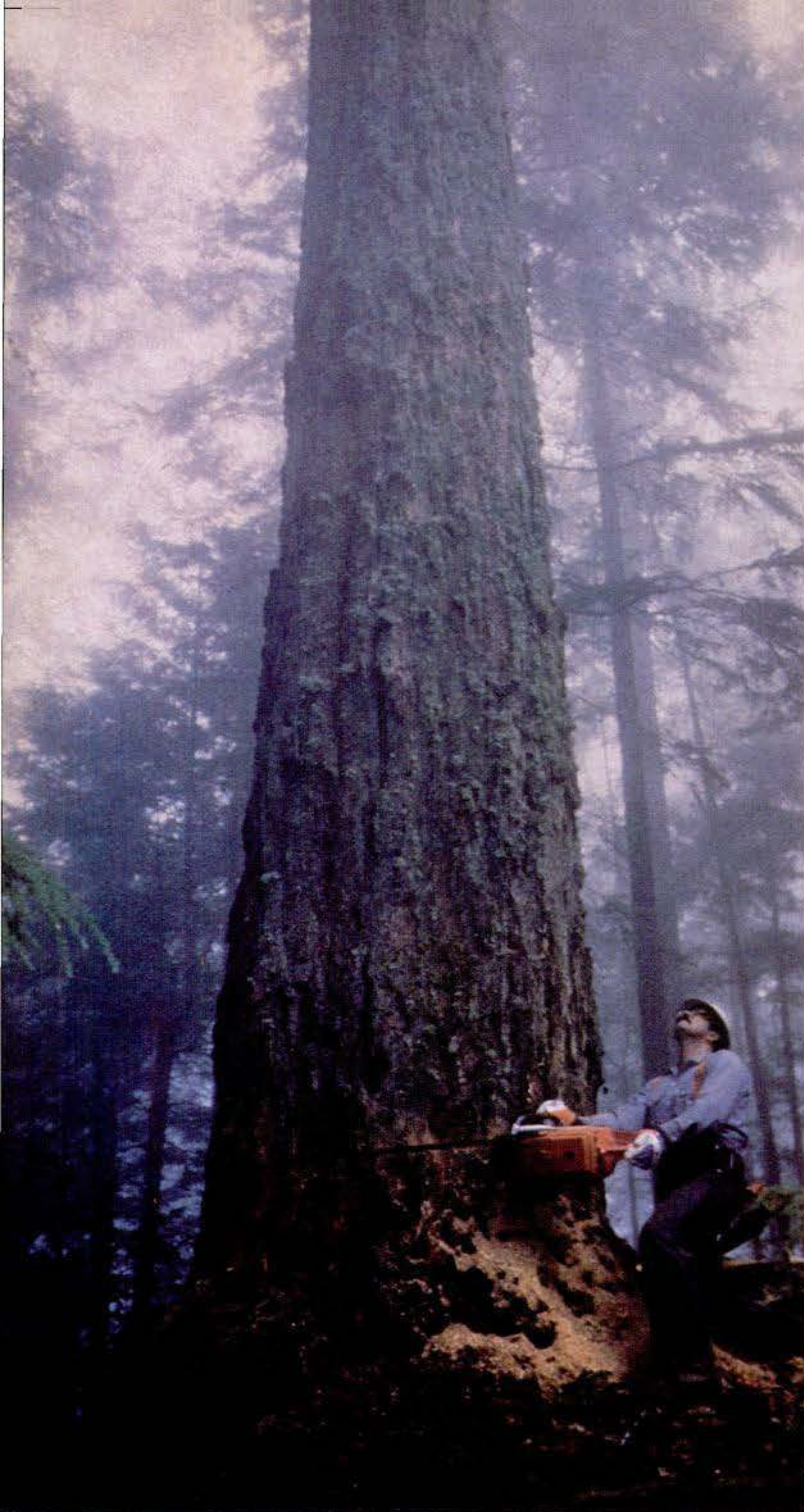
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HUSKY HUSQVARNA



Stealth's first flight

[Continued from page 49]

on air defense hasn't changed very much no matter what weapons systems we deploy."

Speaking recently at the National Press Club in Washington, D.C., Soviet Premier Mikhail Gorbachev's military advisor, Marshal Sergei F. Akhromeyev, said that if the United States builds the stealth bomber, the Soviets will act to counter it. He did not say how.

Welch had what may be the final word on the matter. "There are two kinds of strategic problems," he noted wryly, "those that are already controversial and those that will become controversial."

Big-bucks bomber

The fight over the mission of the B-2, however, is fading in the wake of the much bigger fight now being waged over its astronomical cost. When the program was launched a decade ago without much controversy because of its secret nature, the price tag was large, but not alarming. By the mid-1980s, the DOD said the cost to develop and build 132 bombers would be \$36.6 billion in 1981 dollars. By 1988 the Air Force said that because of design changes and other reasons, the cost had risen 16 percent to \$42.5 billion in 1981 dollars. The number moved up again this year to \$43.8 billion. Unfortunately, there is no way the B-2 can be bought in 1981 dollars. And in the inflated dollars that would have to be used, that \$43.8 billion turns into \$70.2 billion—\$530 million per plane, by far the most expensive aircraft ever built. Congress, as a result, is suffering from a severe case of sticker shock.

The half-billion-dollar cost includes development, training, spare parts, and many other items. The Air Force says that's not the fair way to state cost. For the planes alone, says an Air Force document, "The average unit production flyaway cost of 132 B-2 aircraft is \$274 million in today's dollars." Seen in that perspective, says Welch, the B-2 "costs only twenty percent more than the B-1."

Welch accuses Congress of not really trying to figure out whether the B-2 is worth it or not. "It's just simply the size of the number" that has everybody frantic, he says. And Donald J. Atwood, Deputy Secretary of Defense, says, "When some members of Congress say we cannot afford a strategic manned bomber, they really mean that they do not want to cancel lower priority programs to pay for it."

But the critics won't let up either. Former Under Secretary of Defense Robert Costello recently said in an interview with the *Washington Post* that the program should be killed. And Rep. James Traficant Jr. was unimpressed after the first flight. "My God, it can fly," he said. "What next, a \$100-million Batmobile?"

Invisible plane, visible price

After heavy debate, the House of Representatives voted to cut the B-2 1990 budget request from \$4.7 billion to \$3.7, to reduce the number of planes the Air Force could buy next year from three to two, and to require Defense Secretary Cheney to submit a cheaper overall plan, which, says Rep. Aspin, must contain an overall reduction in the number of planes requested. The Senate passed a less restrictive bill. As of this writing, the outcome, to be determined in a Senate-House conference, is unclear. Says Rep. John G. Rowland: "We didn't ground it, but we sure clipped its wings."

"Right now, I would say it's an uphill fight for the B-2," says House Speaker Thomas Foley. For while the stealth's advanced engineering may make it nearly invisible to radar, its \$70-billion price tag makes it the most visible target seen by legislative antennas in decades.

P 5

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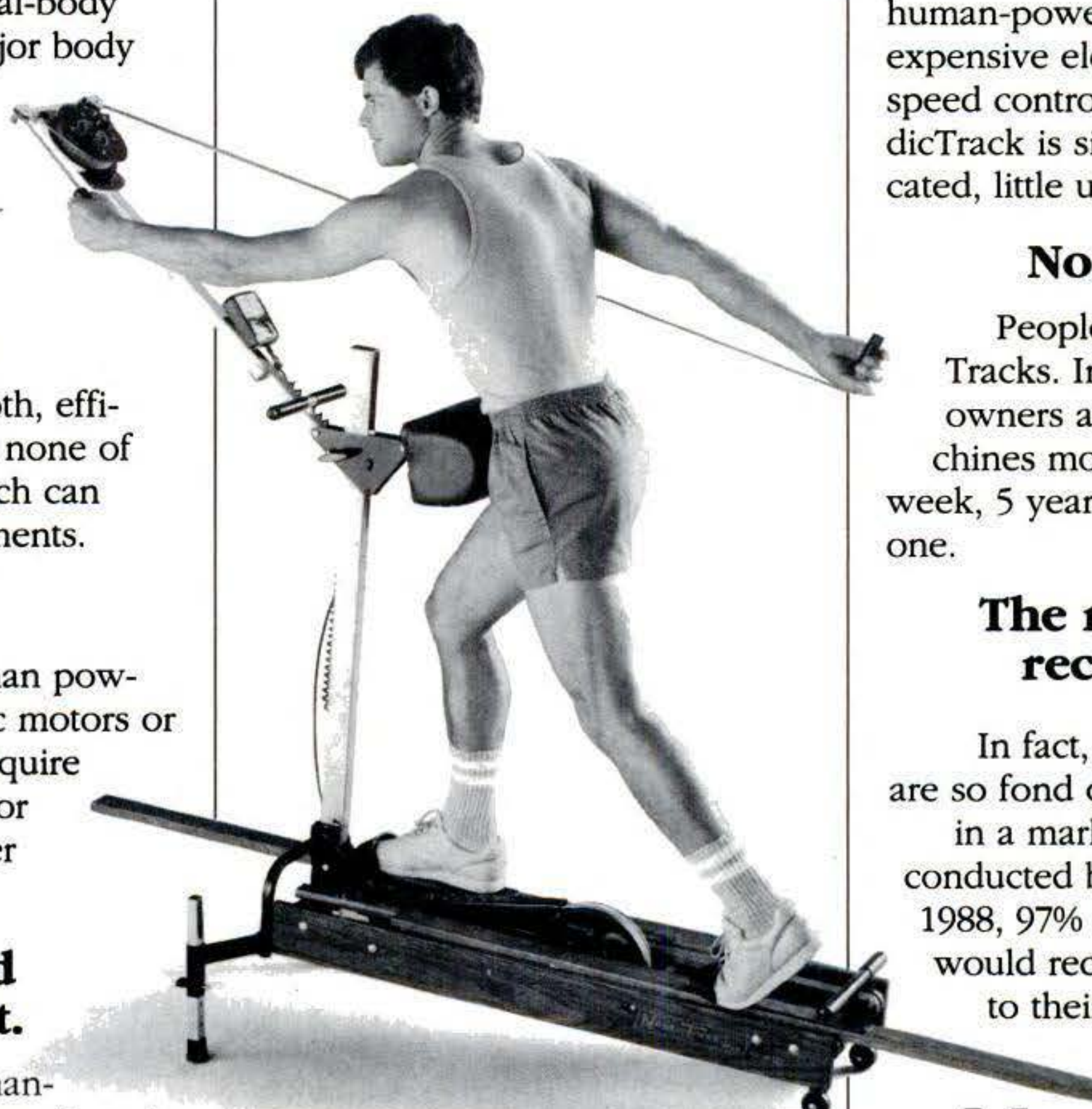
Quieter.

NordicTrack's smooth skiing motion is inherently quiet and has none of the pounding foot step noise associated with running on a treadmill.

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Put a NordicTrack wherever

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280J9

Saving the planet [Continued from page 56]

of oil had plummeted to less than \$12 a barrel last fall, and the synfuels program is mostly foundering.

Wind and solar

The same conditions have hindered the development of both wind and solar energy projects. Both are attractive, both are at the mercy of cheap oil. The leading sources of energy in the United States (numbers approximate) are oil, 43 percent; coal, 24 percent; and natural gas, 23 percent. Nuclear supplies about six percent, and hydroelectric power, for which virtually all practical sites in the United States have already been exploited, trails with four percent.

On a precisely drawn pie chart of energy supply, wind and photovoltaic energy would hardly occupy visible slices—crumbs, more likely. True, California's 17,000 wind turbines generate enough electricity to satisfy the requirements of Washington, D.C.'s residences. But that's a tiny fraction of wind power's potential. According to a study by the General Electric Space Division, if the country were saturated with enough wind farms to take advantage of all our high-wind

areas, the turbines could supply about 40 percent of the total U.S. electrical demand.

Similarly, the brilliant prospects of photovoltaics—direct conversion of sunlight to electricity—have been dimmed. The reason: much further research and development are required to bring the capital cost of a peak watt from a photovoltaic installation—now about \$5—down to \$1, to compete with fossil fuels. Investment by both industry and government in solar energy research has been dwindling steadily; federal funding sank from a high of \$160 million a year during the Carter administration to \$35 million in 1988. A significant number of major U.S. players have simply deserted the field in the last few years.

Ironically, this retreat is occurring at the same time as several technical breakthroughs, including a record efficiency of 31 percent for a solar cell achieved at Sandia Laboratories [Cover story, May]. Still, the cost of electricity from photovoltaics is some five times higher than from electric utilities, on average: 25 to 35 cents per kilowatt-hour as opposed to about six cents per kilowatt-hour, according

to the Solar Energy Research Institute.

Fusion power matches the profile of an ideal energy source—limitless and essentially nonpolluting. But progress toward achieving a fusion reactor that is feasible from both an engineering and an economic standpoint has been painfully slow. The bitter joke inside the fusion community is that such an outcome lies 25 years into the future—and has done so for the last 40 years.

A Magnetic Fusion Community Position Paper issued last May set forth these goals: ignition achieved in the 1990s with a proposed facility called the Compact Ignition Tokamak, or CIT. (Ignition is the point at which the hydrogen gas plasma in which fusion occurs keeps itself hot by means of its own fusion reactions, while generating considerable power output as well.) This would be followed by an International Thermonuclear Experimental Reactor (actually an engineering test reactor) to be completed around the year 2000. If that test is a success, next would come a fusion power demonstration plant in the first quarter of the 21st century.

That schedule, like many in the

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Julian Hirsch, Stereo Review, Sept. '88

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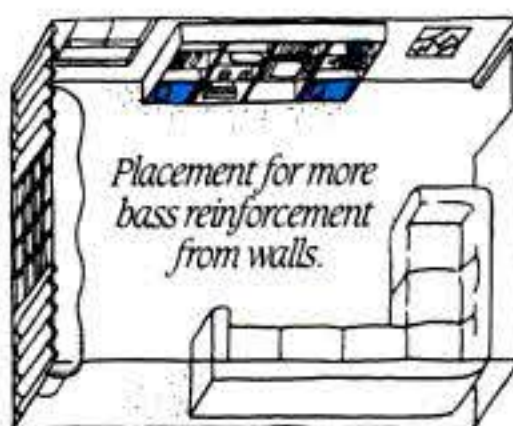
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past, may be over-optimistic. On June 15, Energy Secretary Admiral James Watkins notified the chairmen of various congressional committees that "Due to lack of key scientific unknowns, the Department is no longer proposing to begin actual construction of this device (CIT) in FY [fiscal year] 1990...I am now convinced that the CIT will be unlikely to meet the key ignition goal..."

The Energy Department's present approach to fusion, as outlined in a still-tentative draft on policy, appears to be to postpone a decision between magnetic confinement fusion, represented by the tokamak, and inertial confinement, as in laser devices, until "early in the next century." Therefore "the Department does not plan to request sizable increases to the DOE budget to construct either of the near-term-ignition devices" (the CIT or a proposed inertial confinement device called the Laboratory Microfusion Facility).

No-lose nuclear?

Nuclear power? It once seemed to offer a no-lose energy option. But it has been beset by a truly baroque con-

stellation of ills, from mismanagement and cost overruns (some still recall the early promise that nuclear electricity would be "too cheap to meter") to concerns over safety and the real problems of waste disposal and decommissioning. The accidents at Three-Mile Island and Chernobyl served to make the citizenry of some countries, notably the United States, leery indeed about energy from the atom. The result in this country is that no new nuclear power plants are now planned, none is being built, and a \$5.5 billion finished plant that is ready to begin operation (LILCO's Shoreham plant on Long Island, N.Y.) may be sold for a dollar and dismantled.

But the threat of global warming has made some environmentalists willing at least to reconsider the potential of this no-greenhouse-gas process. In this context, it is worth looking at the present contribution of nuclear power worldwide.

The International Atomic Energy Agency reports that nuclear energy supplied 1.8 trillion kilowatt-hours of electricity in 1988, nearly 17 percent of the world total.

"While that does not appear to be a

very large share," says the Agency's director general, Dr. Hans Blix, "to replace it would require the equivalent of the entire coal production of either the United States or the Soviet Union."

The 17 percent share was generated by 417 commercial plants in 25 countries. Half of those countries derived at least 25 percent of their electric power from nuclear plants, with France heading the list at 70 percent. Sweden's mark was 47 percent, Japan's 28 percent. In the United States, 112 nuclear plants generate about 20 percent of the nation's electrical output. Nuclear here is the second largest producer of electricity; only coal generates more.

Coal, of course, is the dirtiest of the fossil fuels from the standpoint of CO₂ emissions. And moving away from this energy source on a global basis will be difficult.

Mark A. Harwell, an ecologist who is director of Cornell University's Global Environment Program, visited China last fall.

"The Chinese authorities and scientists I met with told me they intend

Continued

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Saving the planet *Continued*

to double or triple their coal production in the next twenty-five years," he says. "Now, I don't care what kind of energy efficiency we impose on the United States, that's going to more than swamp our signal."

"Yet I don't see that we can go to the Chinese and say, 'No, no. You can't do that, because it's going to make the Earth warmer.' They've got a billion people trying to raise their standard of living, and the only energy resource they've got that's capable of doing it is coal. The one thing we can do is help make a tremendous improvement in the efficiency with which China uses coal. That would have a real impact."

Still, any move away from the fossil fuels will help.

"We will have to move very aggressively with nuclear energy if we are going to mitigate the effects of the CO₂ problem," Alvin Weinberg told an international conference on the enhanced safety of nuclear reactors in August 1988, where a number of designs for reactors, simpler and allegedly safer than present ones, were discussed. Weinberg, of the Oak Ridge Associated Universities, is one of the world's foremost energy analysts. He pointed out that France, heavily invested in nuclear plants, has reduced its emissions of CO₂ into the atmosphere by 30 percent, while maintaining a good safety record.

Environmental dilemma

The global warming issue, Weinberg says, creates a curious dilemma for environmentalists. "They are correct when they say that nuclear power can't do the whole job alone, but conservation cannot do everything either."

Not everything. But to many experts it offers what may be the only serious candidate for salvation. Most agree that futuristic macroengineering projects like orbiting space shields will not be attempted, that there will be no large-scale abandonment of coal-burning electric power plants in the near future, that Third World countries will not—without powerful incentives—reject economic development, including the clearing of tropical forests, to save the rest of us.

But a gradual spreading of the conservationist creed, especially in the industrial countries, might be a powerful antidote to the greenhouse gases. Despite some recent backsliding, this country, for example, has had some remarkable successes starting in the early '70s:

From 1973 to 1986, U.S. energy use remained level, while the gross national product increased 40 percent.

And improvements were not confined to the United States.

"The world has saved far more energy [since the Arab oil embargo of 1973] through improved efficiency than it has gained through all new sources." That is the conclusion of Christopher Flavin and Alan B. Durning in a 1988 World Watch Institute report titled "Building on Success—the Age of Energy Efficiency." And there is certainly room for more improvement, especially in the United States.

"We currently spend ten percent of our GNP [gross national product] on energy services," says Arthur H. Rosenfeld, "compared to five percent for Japan." Rosenfeld is professor of physics at the University of California, Berkeley, and director of the Building Science Center of the Lawrence Berkeley Laboratory.

"Improving energy efficiency in buildings, industry, and transportation can cap world fossil-fuel use, delay global warming for twenty to forty years, and provide time necessary to develop safe, reliable, renewable energy supply options such as nuclear, solar, ocean, and wind power, all of which are expensive now but should be cheap in twenty to forty years...."

"If the U.S. were still operating at 1973 efficiency levels, we would have pumped fifty percent more carbon dioxide...into the atmosphere during 1986. But we can do much better. In fact my personal target is to reduce the total U.S. energy consumption per unit of GNP by 3.5 percent a year. This would permit 2.5 percent annual growth and still cut U.S. energy use and fossil-fuel emissions by one-half over the next seventy years. The technology to do this is already available—such as more energy-efficient lights, windows, appliances, motors, and cars—but we need economic incentives."

Pointing to the ominous fact that in 1987, for the first time in history, the U.S. transportation sector consumed more oil than we produced, Rosenfeld calls for a tax on gasoline and a combination of fees and rebates—keyed to mileage per gallon—for purchasers of new cars.

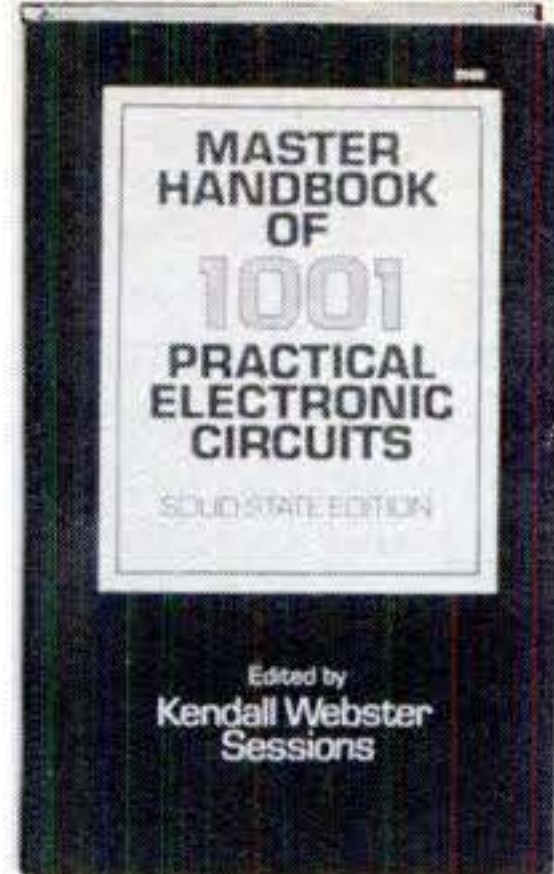
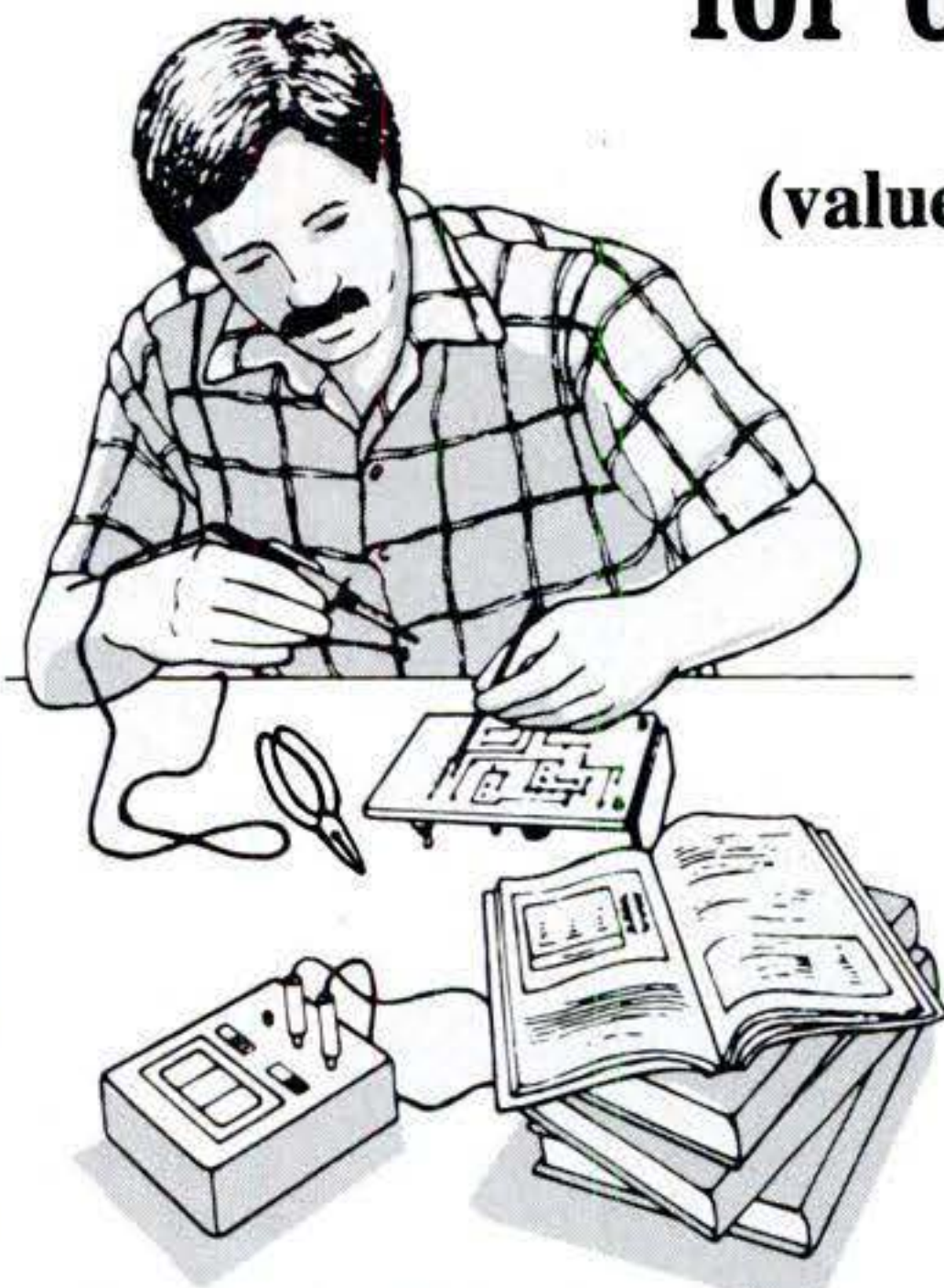
The greenhouse effect is blind to the methods by which we achieve conservation, whether through mutual cooperation—a sort of new social contract—or through stern measures imposed by law. Both may be needed to effect another essential form of conservation. Beyond conserving energy, the world needs to conserve and expand the living forests.

The combination of halting defor-

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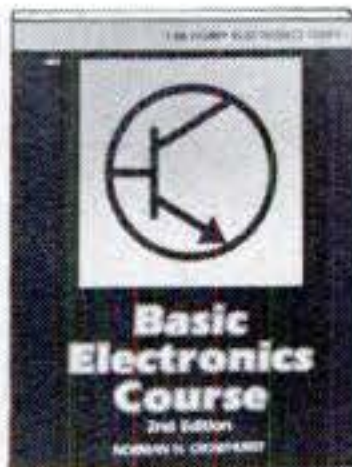
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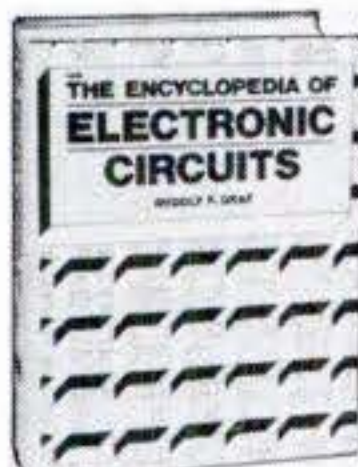
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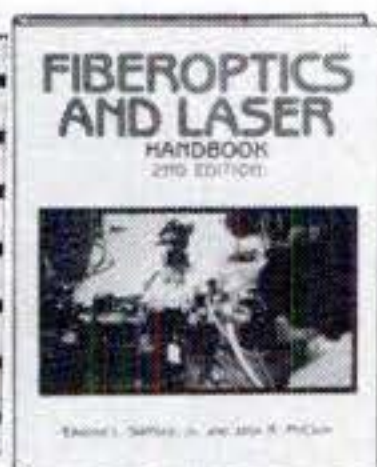
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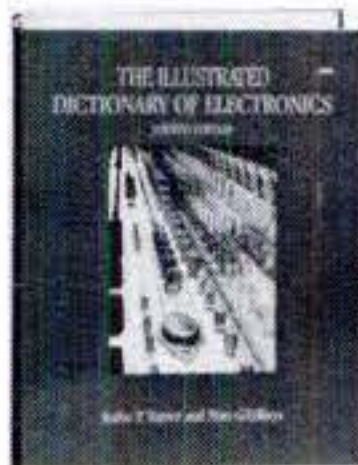
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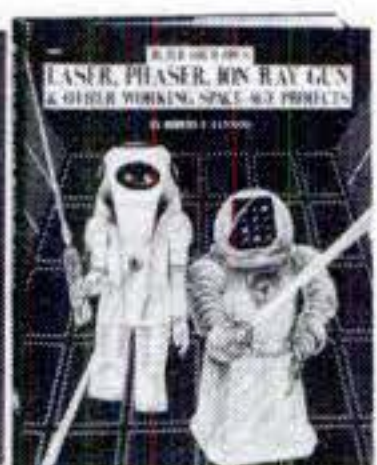
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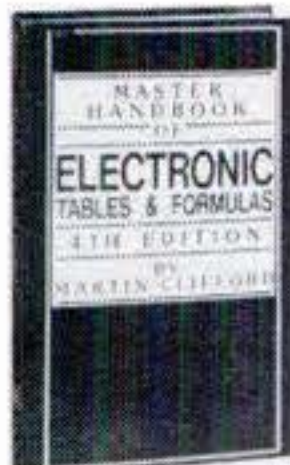
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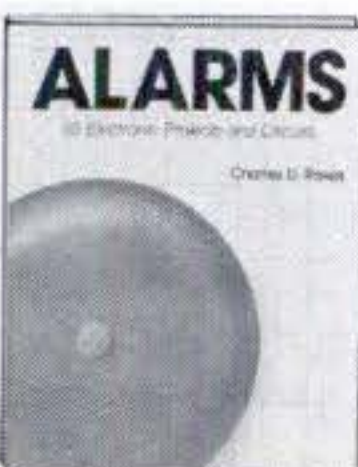
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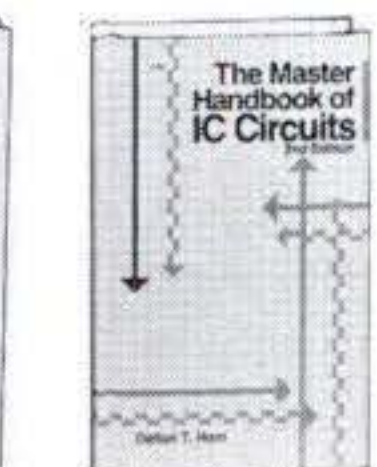
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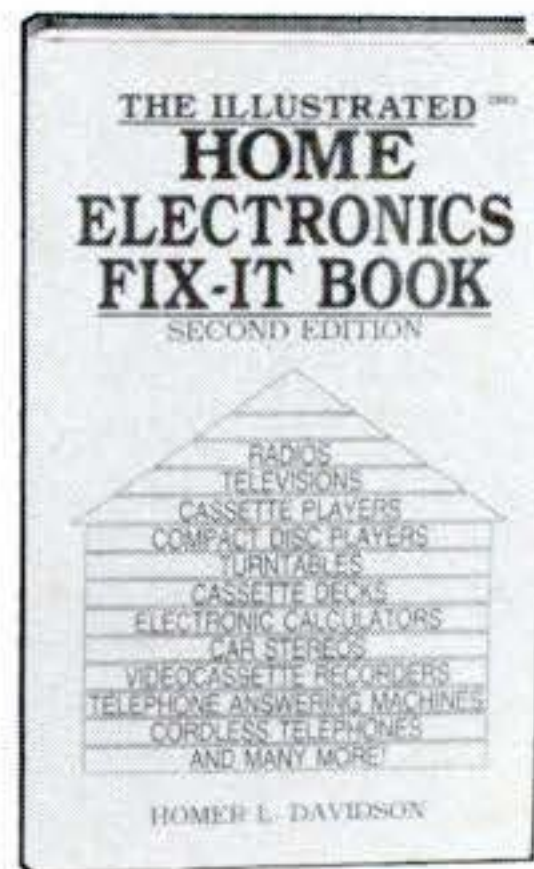
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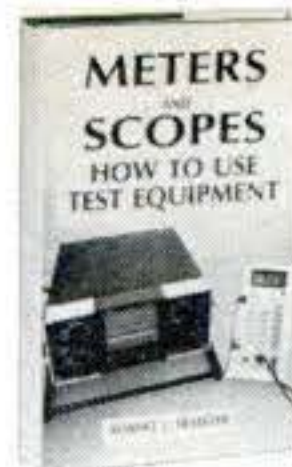
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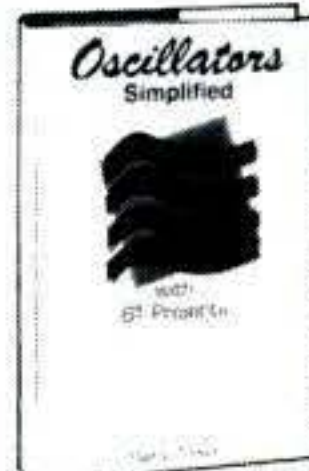
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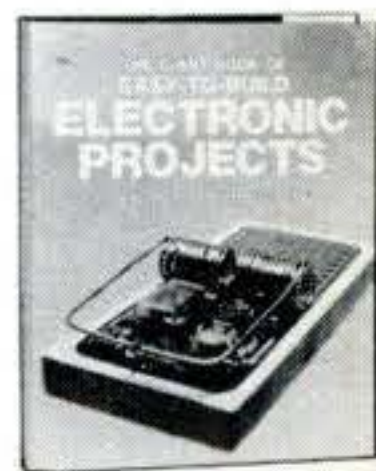
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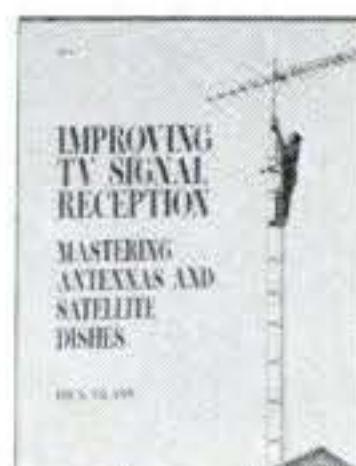
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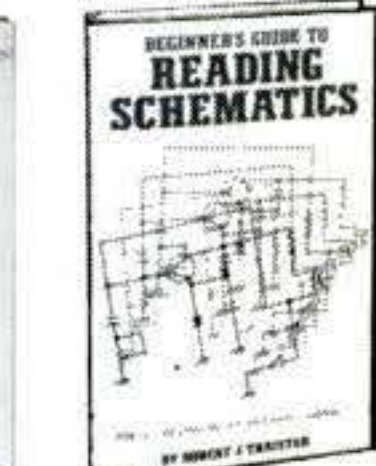
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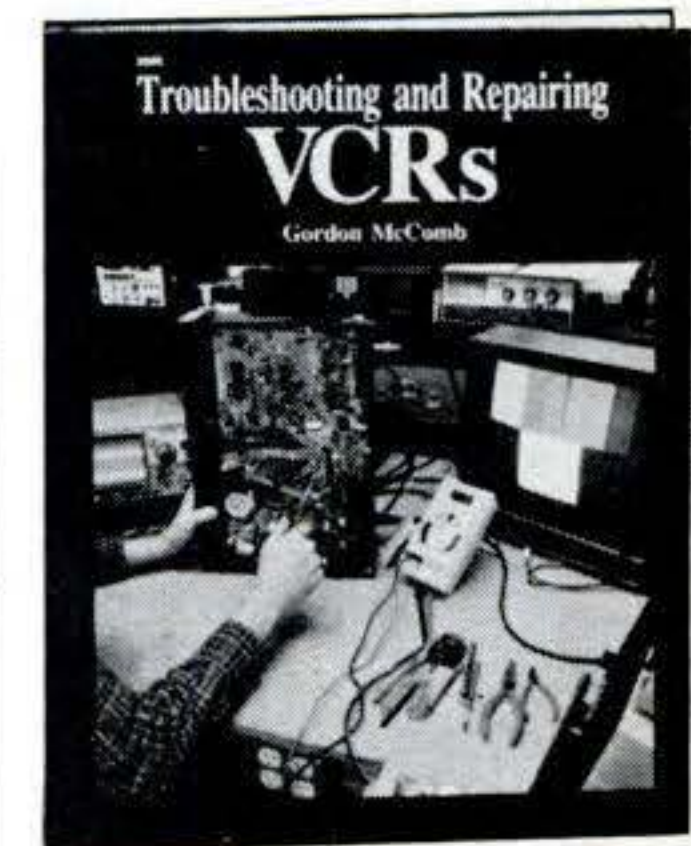
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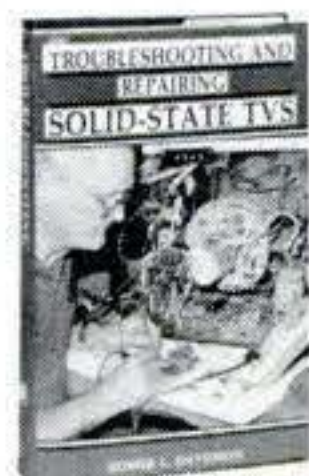


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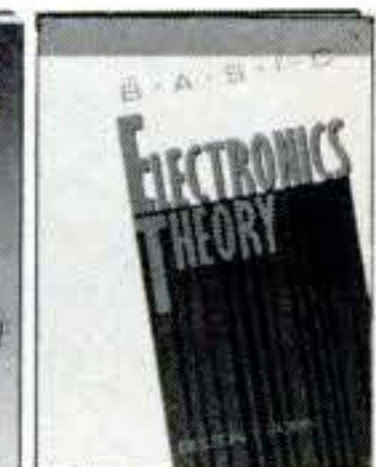
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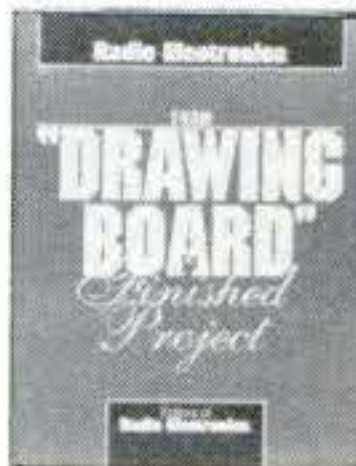
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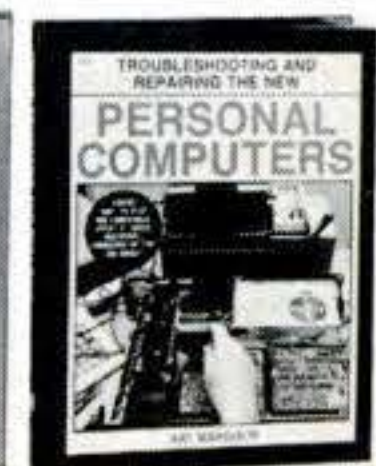
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Saving the planet *Continued*

estation and planting trees has the effect of terminating the steady erosion of a carbon dioxide sink while increasing the net absorption of the greenhouse gas. Moreover, planting urban trees promotes cooling and so reduces the air conditioning load—another energy saving.

Says Rosenfeld: "The recipe is this: Pay \$15 to \$75 to plant and water three trees around a house, wait ten years for the trees to grow, and then save about 750 to 2,000 kilowatt-hours per year in air conditioning energy per house—worth \$50 to \$150 each year." The American Forestry Association has begun a national program destined to achieve the planting of 100 million trees in cities across the United States by 1992.

How many trees?

Other tree-planting schemes are far more ambitious; they would tax the stamina of a legion of Johnny Appleseeds. Daniel J. Dudek of the Environmental Defense Fund, in testimony before Congress in September 1988, urged the planting of 10 million acres of trees (an area twice the size of New Jersey). This, he said, would absorb all the carbon dioxide emitted for the next 10 years by new coal-burning power plants to be built by U.S. utilities.

How much new forest would it take to absorb an extra, say, five billion tons of carbon each year—about equal to the amount emitted by fossil fuel burning? Gregg Marland of Oak Ridge National Laboratory has calculated it would take an area the size of Australia, about equivalent to all the tropical forest man has cleared since he invented agriculture 10,000 years ago.

On a considerably smaller scale is the so-called "offset strategy" by which utilities agree to plant trees in adequate numbers to take up the amount of carbon dioxide their new plants will generate. A much-admired example has been launched by Applied Energy Services. It will contribute \$2 million to the planting of 52 million trees in Guatemala as an offset to its new 180-megawatt coal-fired plant in Uncasville, Conn.

Population control

There is one other role for conservation—keeping the world's population from exploding out of control.

Like most ecologists, Cornell's Harwell believes that population increase is the ultimate driving force behind the enhanced greenhouse problem. And he sees an intimate connection

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Breathing ionized air can help you breathe better, feel better, sleep better and even think better.

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Note: Bi-Polar ionization was invented by Air Ion Devices in 1981, the leading manufacturer in this field. More than 500,000 AspenAir Bi-Polar products are in use worldwide today. Every AspenAir comes with a full 1 year limited warranty.

Discover the difference at no risk!

Try the powerful A-12 for 30 days. Use it where you work, sleep and rest. If you are not convinced that it is the most powerful, affordable and effective portable aircleaner/ionizer you can own, simply return it for a full refund. However, chances are you'll want several before the trial period ends.

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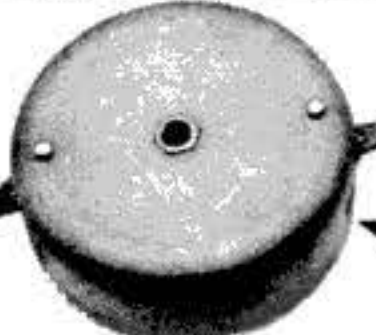
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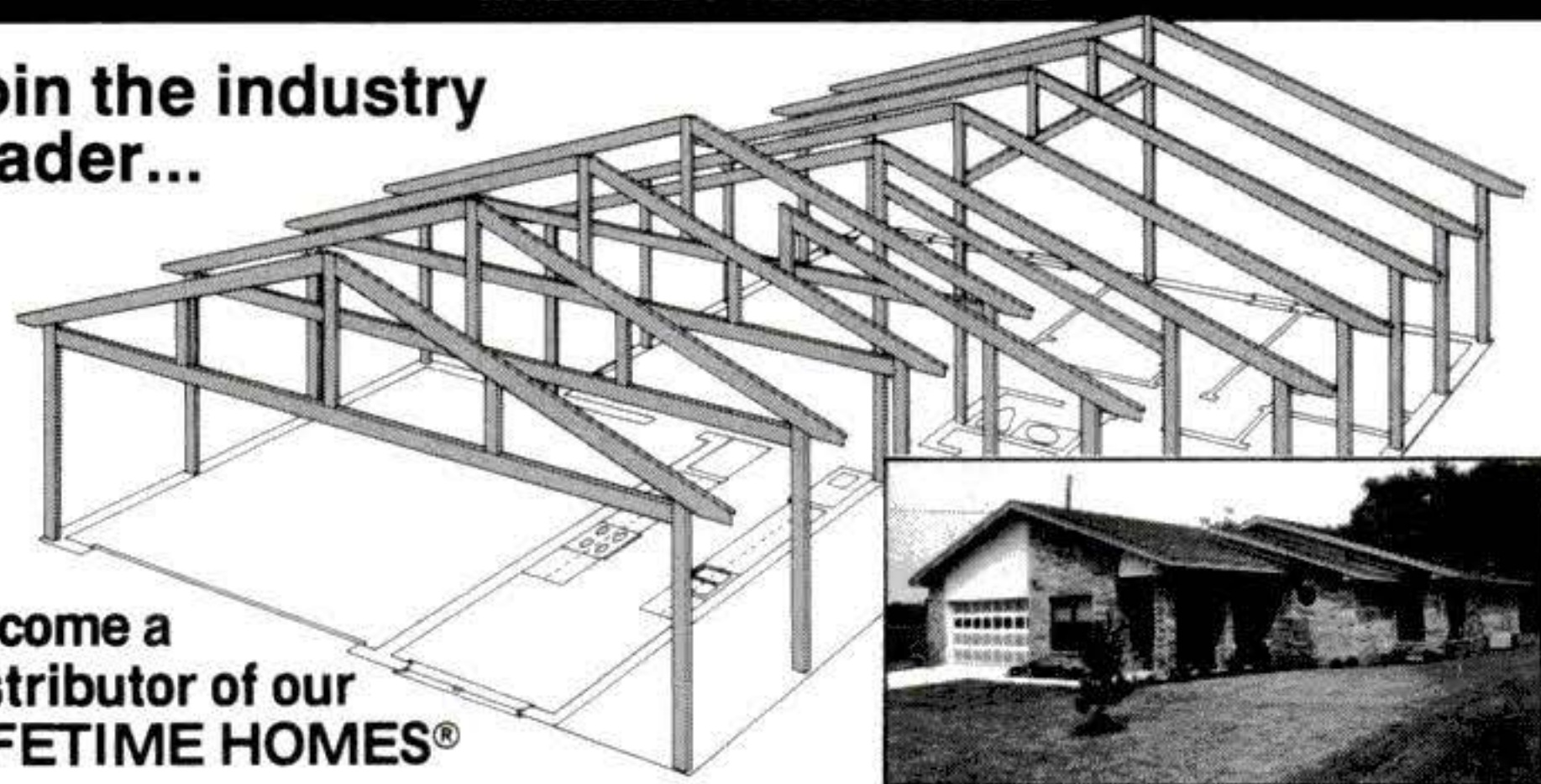
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Saving the planet *Continued*

between population rates and the food shortages that will arise as global warming shifts the distribution of food crops, decreases the amount of water available for grain belts, and shrinks the amount of arable land through sea level rise.

"A farmer in Kansas is likely to find a way to adapt; I don't expect people in Kansas to starve," he says. "But it's a different story in, say, parts of Africa, and similar places where there are tremendous stresses already from over-exploitation of the environment. These are the places where human population growth is outrageous, doubling every twenty-five years. The combination of no reserve food capacity, a stressed environment, and an outrageous population growth rate is leading to terrible consequences in those parts of the world already. If we superimpose a more uncertain and hostile environment through global warming, then it just makes things really grievous."

A case for action

The time taken for the world's population to double is shrinking: It took more than a century for a change from 1.25 billion to 2.5 billion in 1950, but only till 1987 for the next doubling, to 5 billion. In the year 2000 there will be a billion more. In many countries, however, including some of the worst afflicted, population control encounters strong resistance on religious grounds.

There remain those who argue that the case for global warming is not fully proved, that the climatologists' models are fallible, that proposed remedies are too wrenching to be contemplated without further assurances that they are absolutely needed.

One trenchant response to this argument came from an Australian legislator, Barry O. Jones, at the close of the Greenhouse '88 conference in Melbourne. He approached the production of greenhouse gases, he said, in the spirit of Pascal's wager—after the 17th century French philosopher:

"If we take action and disaster is averted, there will be massive avoidance of human and social loss and suffering.

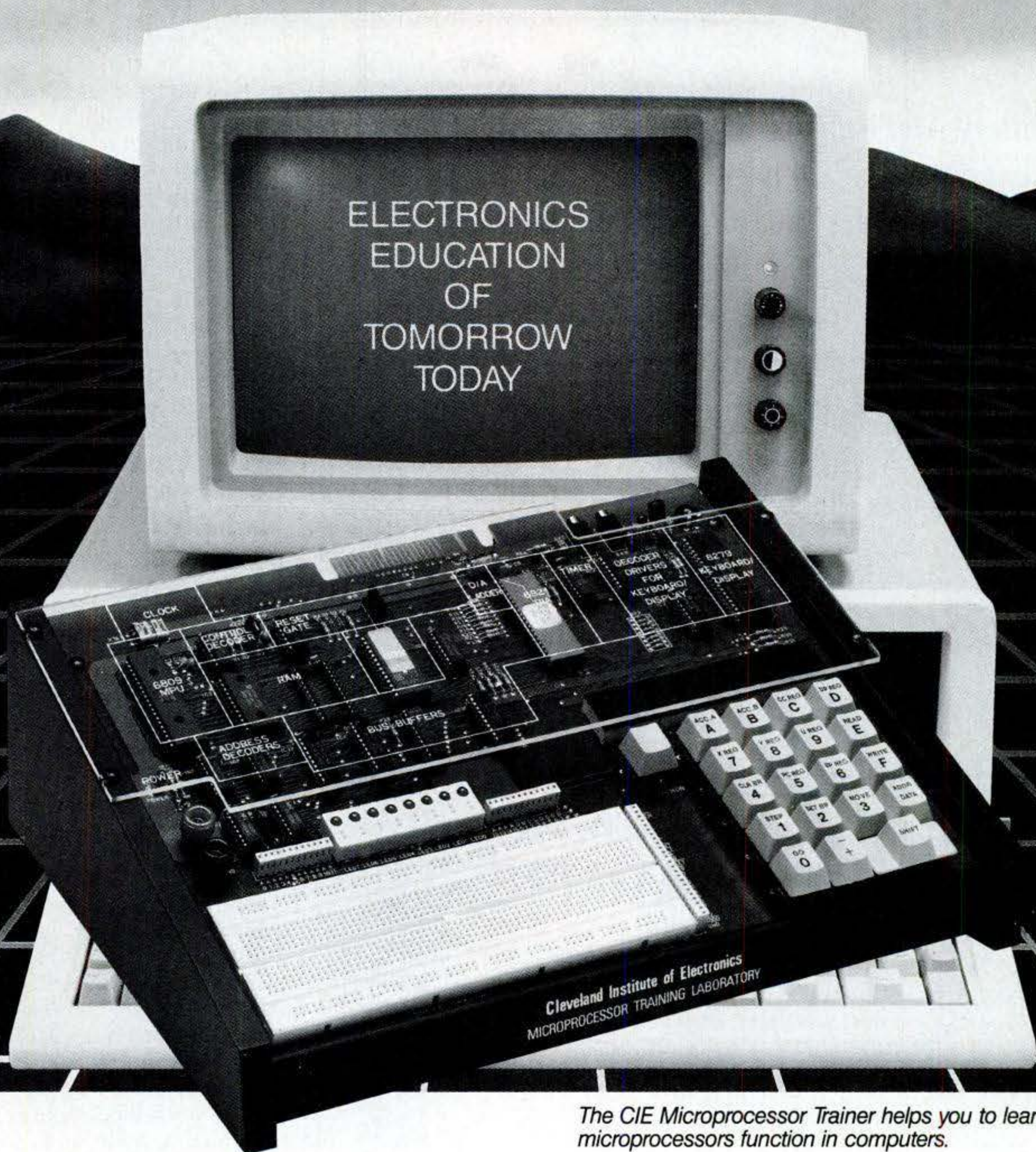
"If we take action and there is no problem (i.e., a period of global cooling occurs for other reasons), then little is lost—indeed we should gain cleaner air and environment anyway.

"If we don't take action and disaster occurs, it will be a vast global tragedy.

"If we don't take action and there is no disaster, the outcome will be due to luck alone."

P 5

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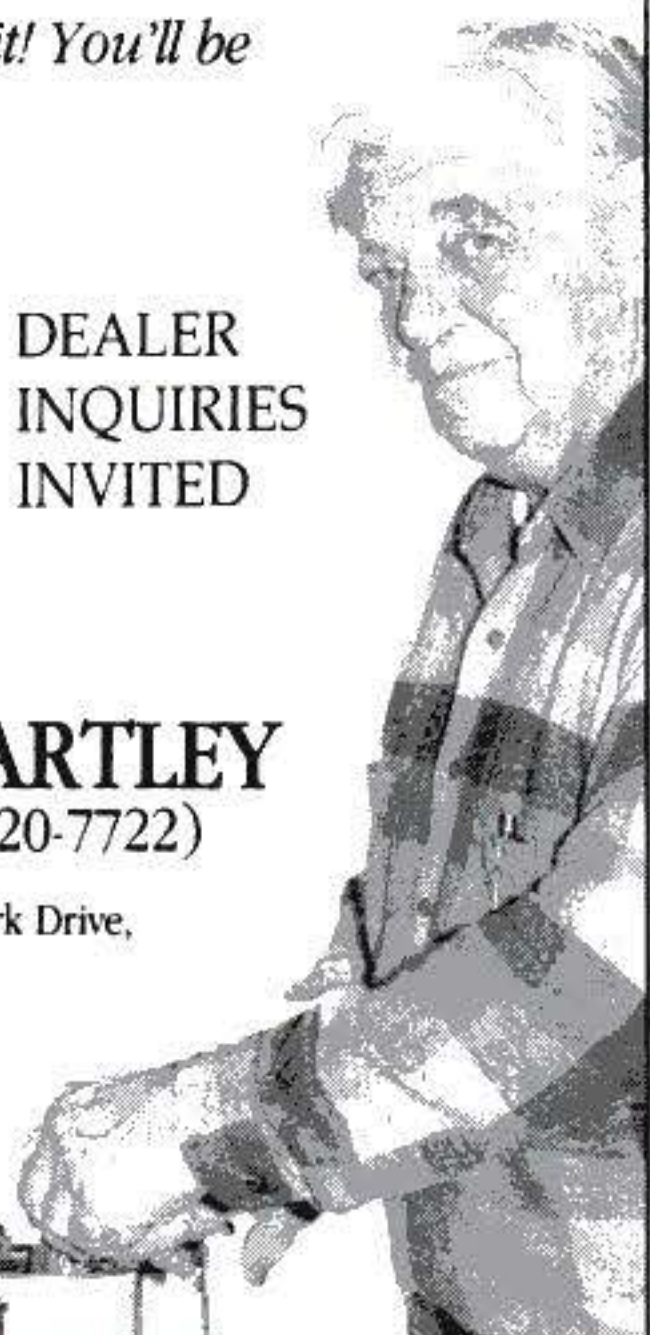


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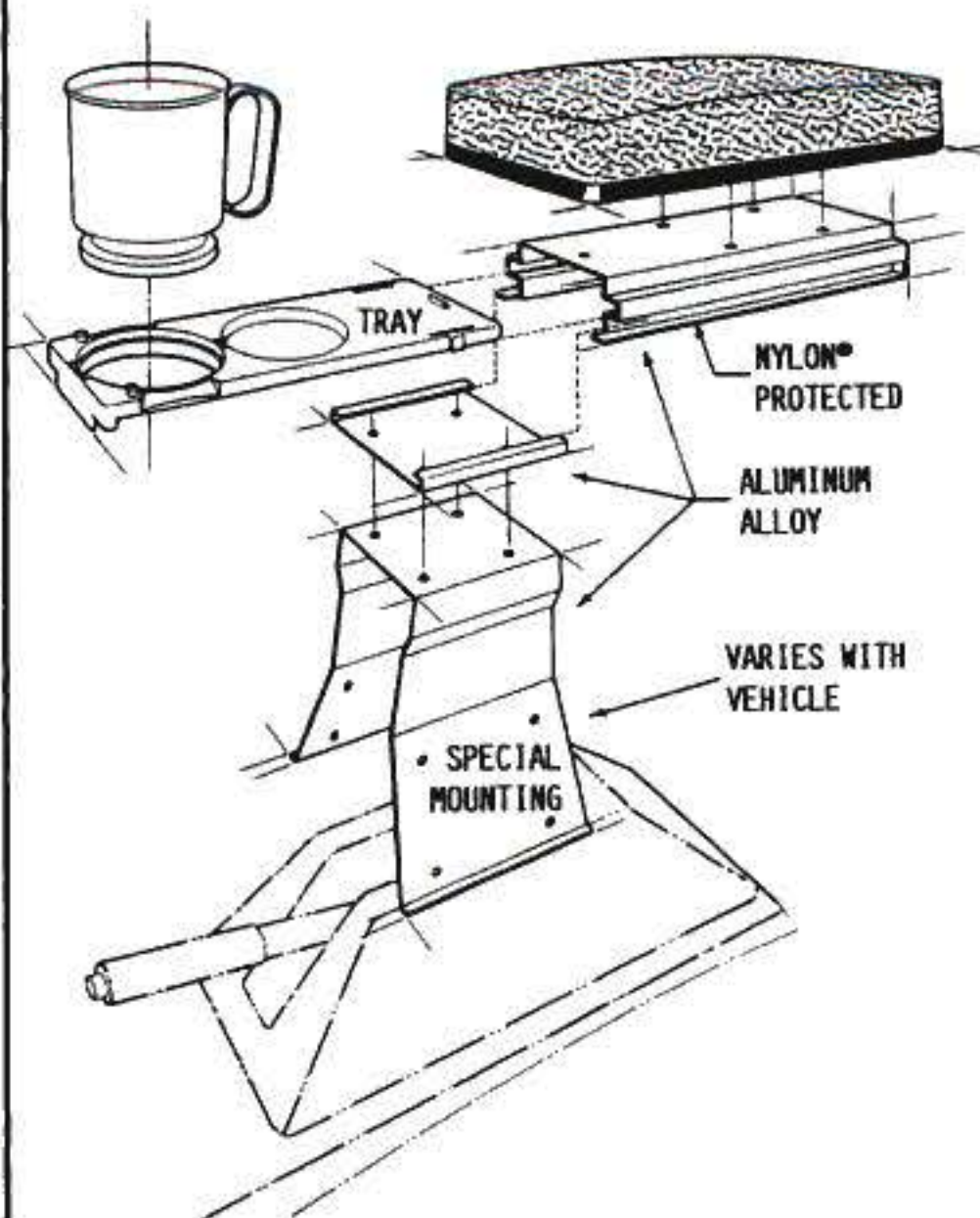
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Home watchers

[Continued from page 77]

be any open window or door down the wire." Now you know. The newest wired systems like Ademco's Vista no longer check for continuity. "We use the wire to carry power and digital signals that communicate with each sensor," says Goldman. "If the sensor detects a burglar, it digitally reports its location to the system."

Most often, the system is an electronic control box that's in touch with a remote central monitoring station via phone line. But there's a problem: "A smart thief could cut the line," says Goldman. So Ademco has an alternative.

"We call it AlarmNet," says Goldman, "and it uses a transmitter at each control box instead of the phone line." To receive the emergency transmission, Ademco has created its own network of multiple antenna towers strategically located to cover a wide area. "Twenty-six towers cover New York City," says Goldman. "If any one of them receives an alarm, it's passed on to the monitoring station."

While an operator at the central monitoring station must verify the alarm (usually by calling your home and asking for a password) and call the police, his role is largely passive. But that's changing too.

Downloading revolution

"The alarm industry has been revolutionized recently by something called downloading," says Goldman. Equipped with a personal computer, the operator at the central monitoring station can now control your alarm system by sending—*downloading*—digital information. For the first time, there is two-way digital communication between electronic systems. And that means additional conveniences too. "Say you left for your vacation and forgot to arm the system," says Goldman. "You can call the operator, and he'll do it for you." He could also change the way your alarm operates. For instance, certain sensors could be turned on or off to allow limited access to your home while you're away.

If computer downloading and radio networks seem elaborate—and expensive—for typical home protection, you're right. But the technology is here now and more is certainly to come. Future home systems will check fingerprints or listen to your voice pattern before you're allowed to enter. And digital transmissions will be made over an enormous spread of frequencies to avoid detection and blockage. "If we can make a digital dog now," says Heath's Krisel, "maybe we can take a real bite out of crime in the future."

P 5

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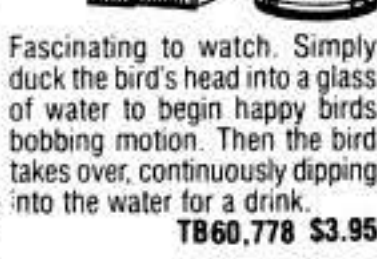


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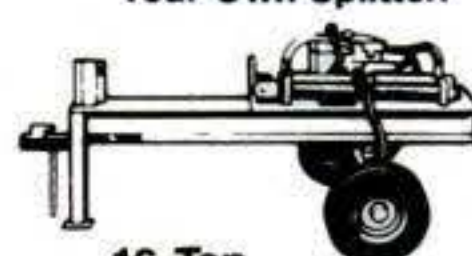
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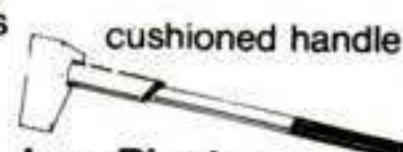
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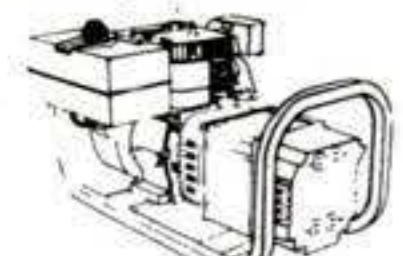


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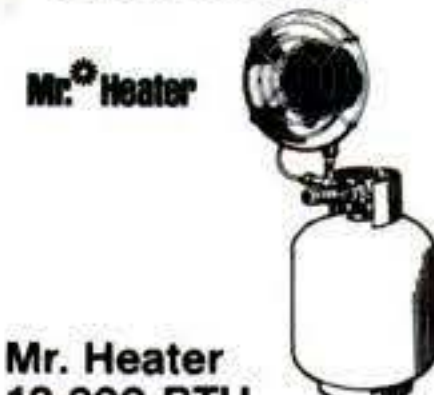
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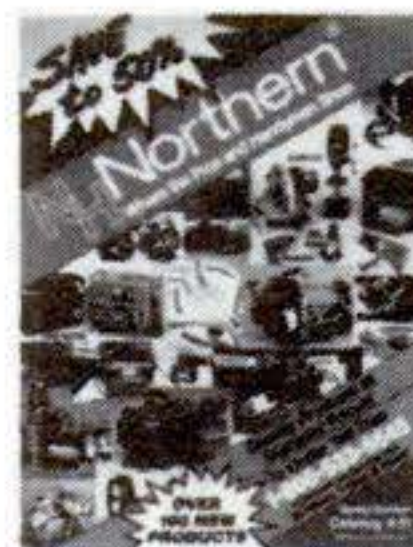
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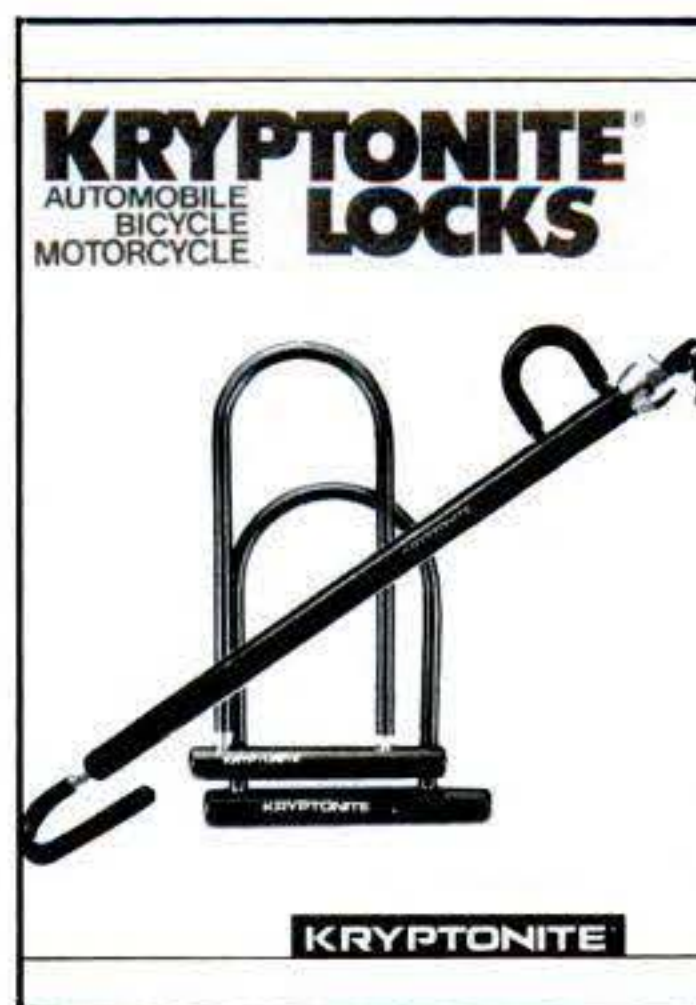
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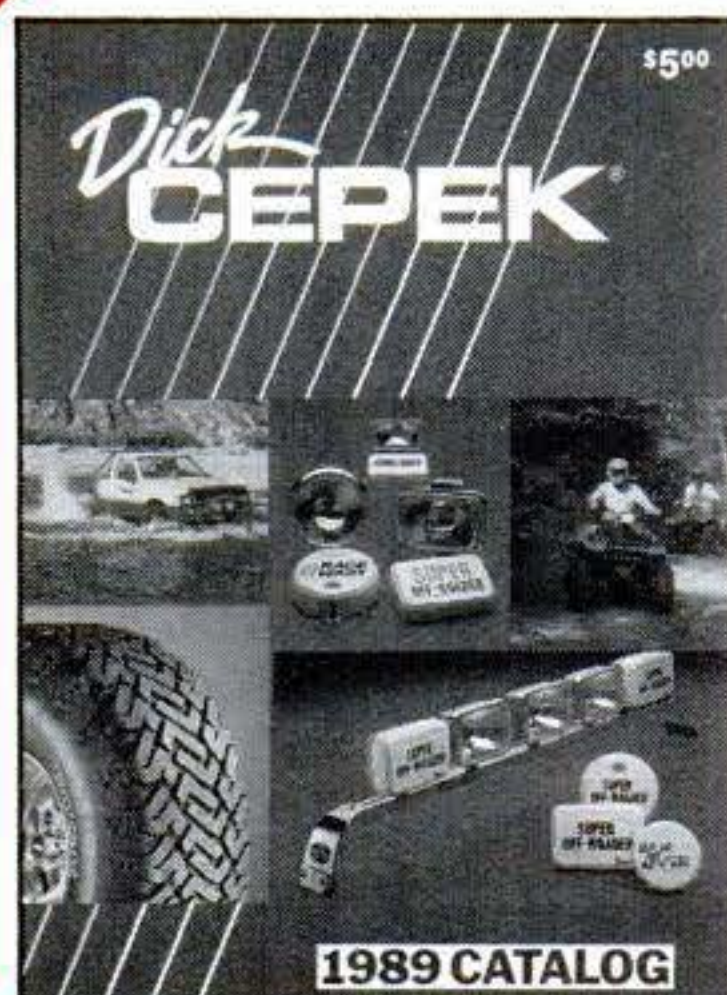
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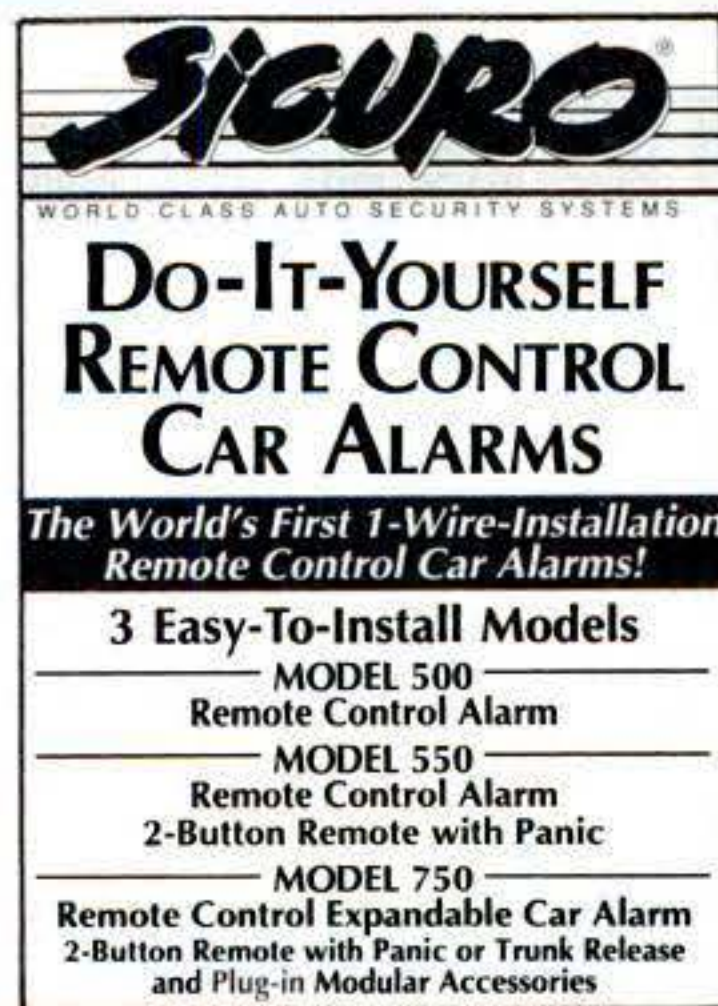
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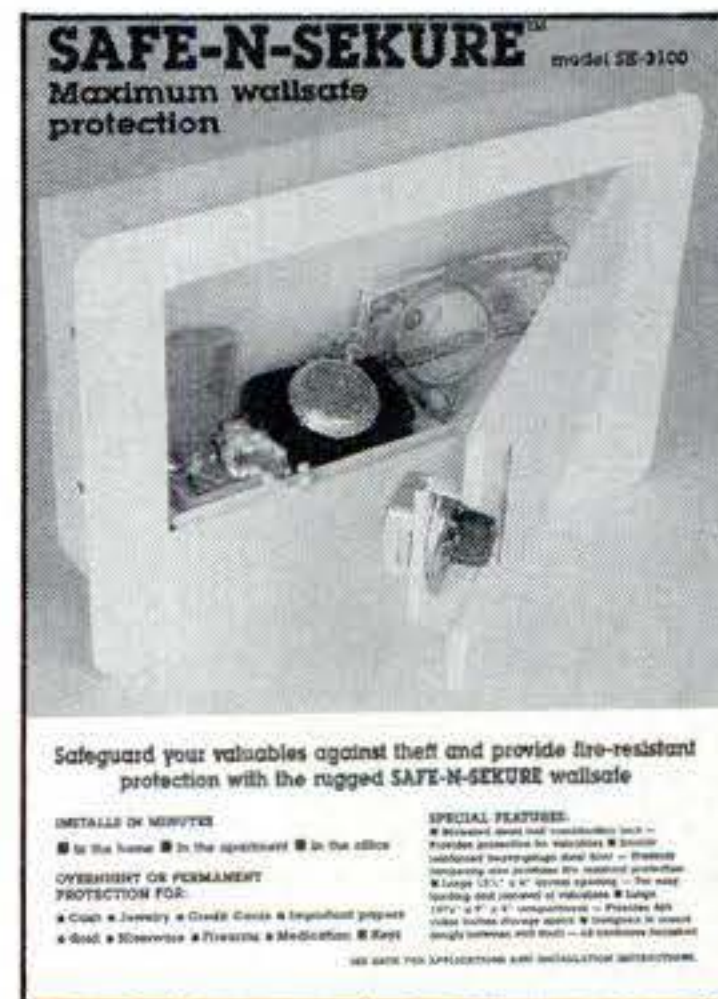
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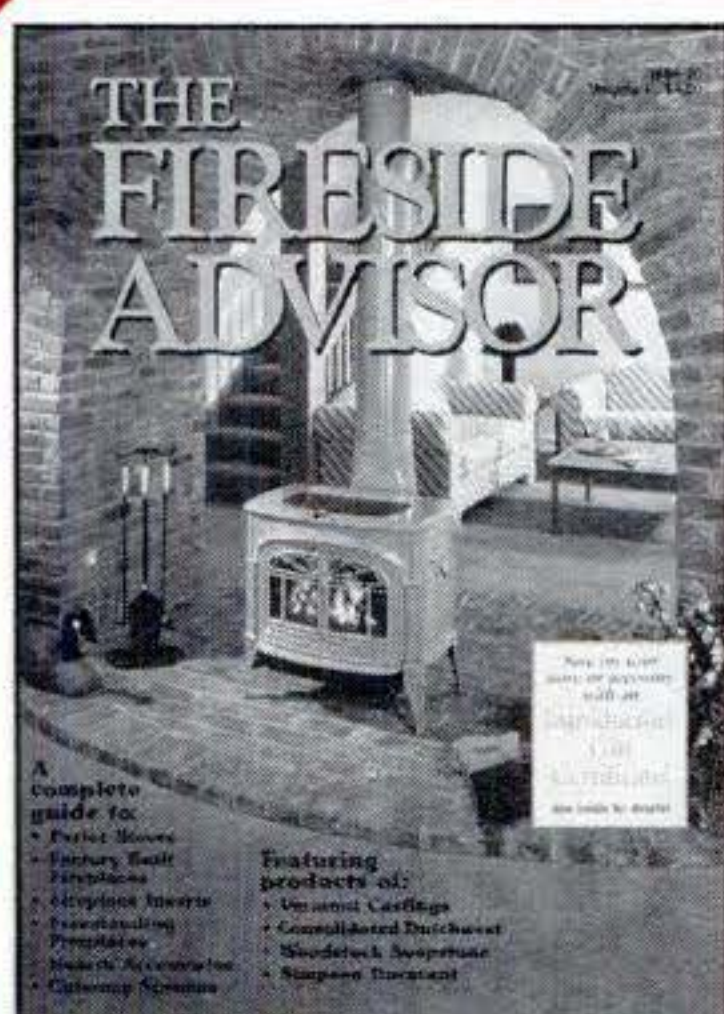
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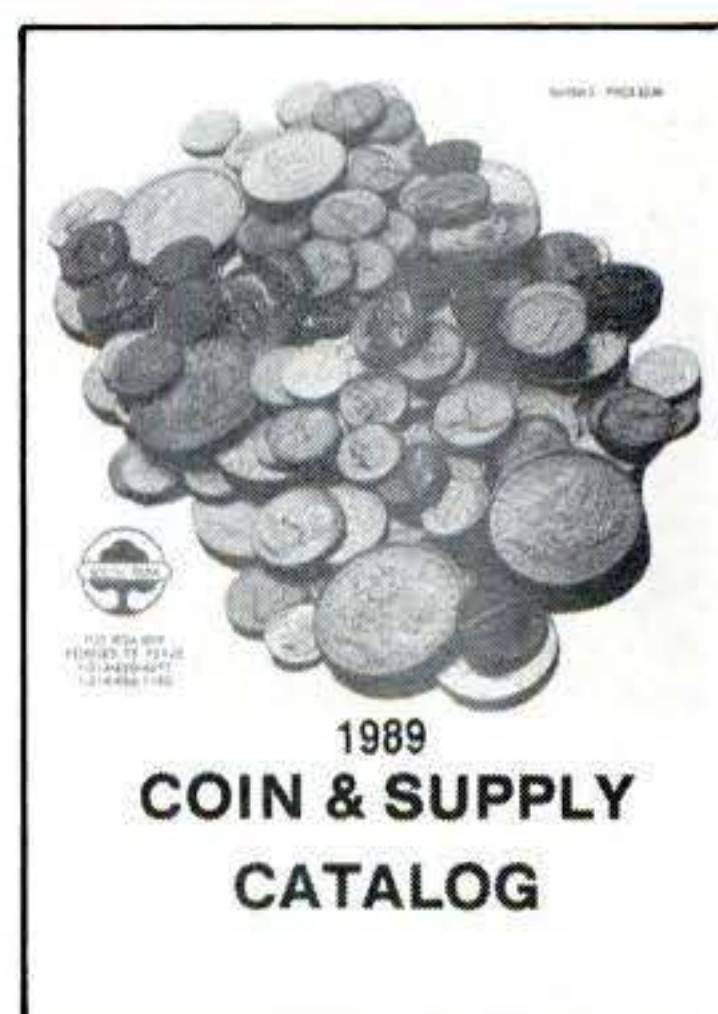
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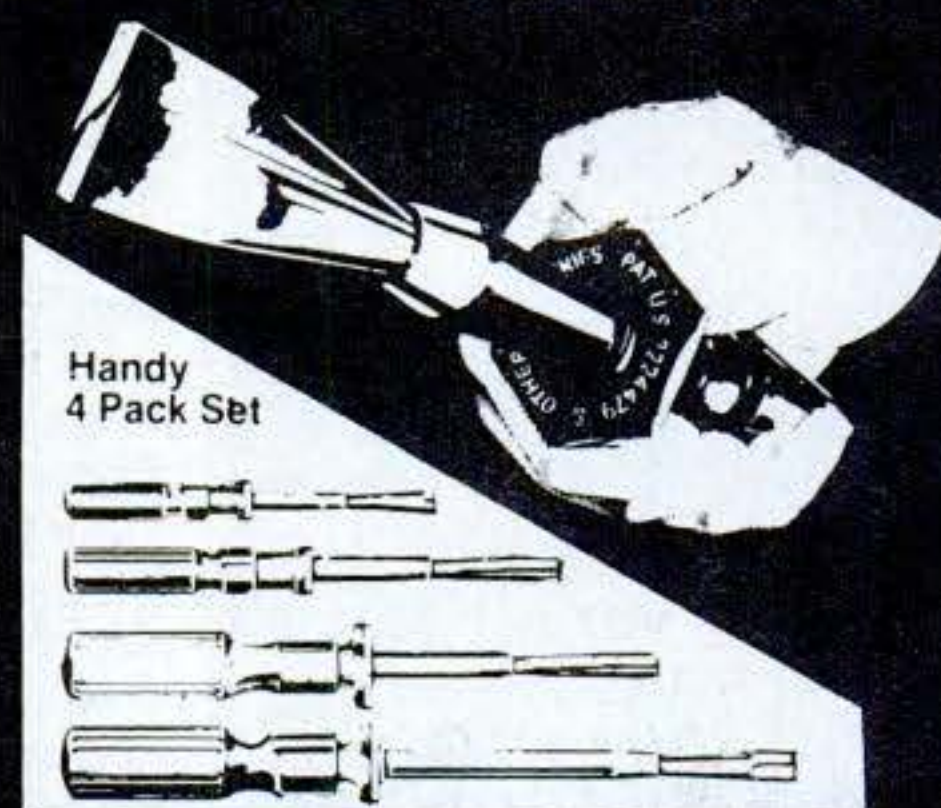
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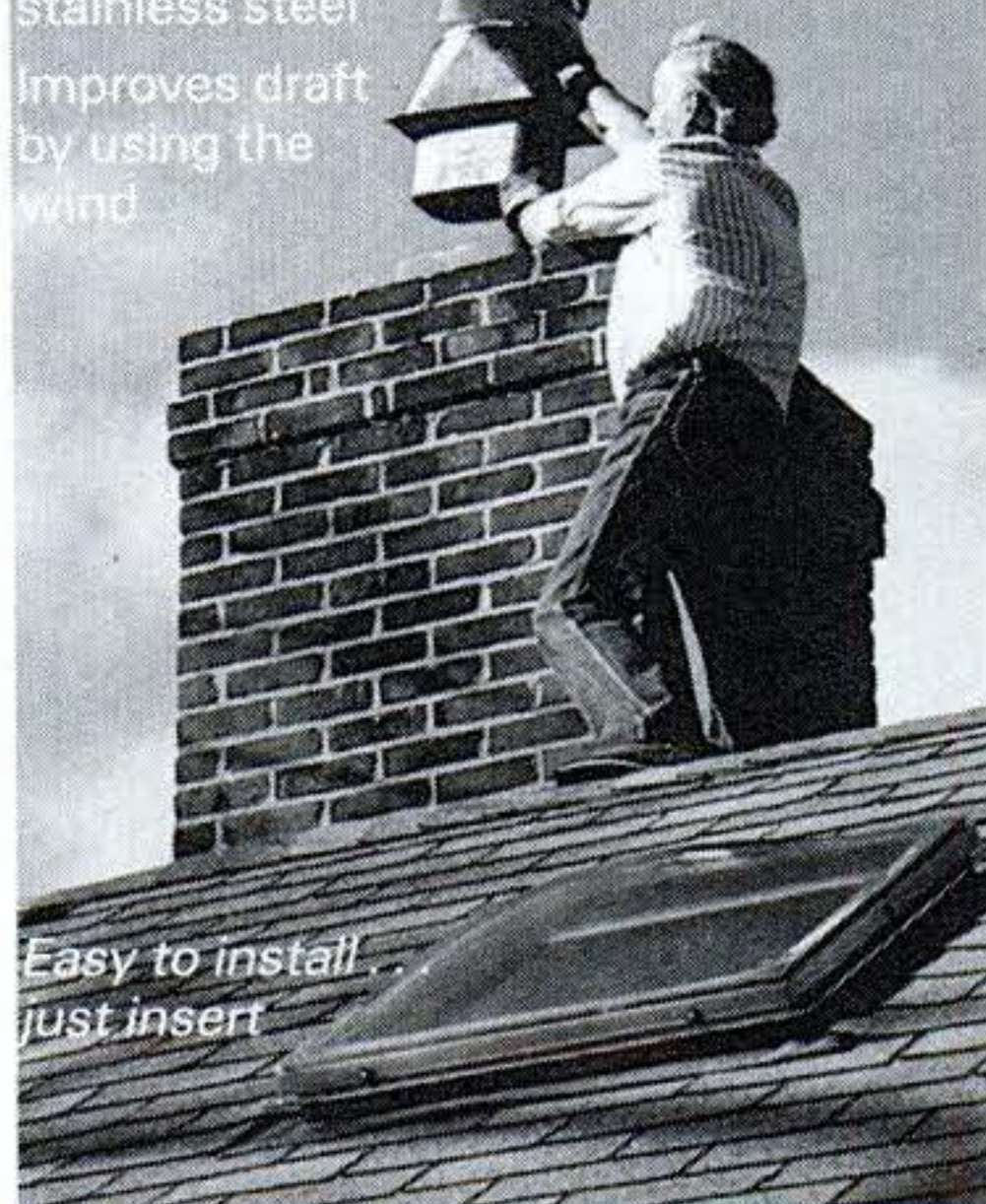
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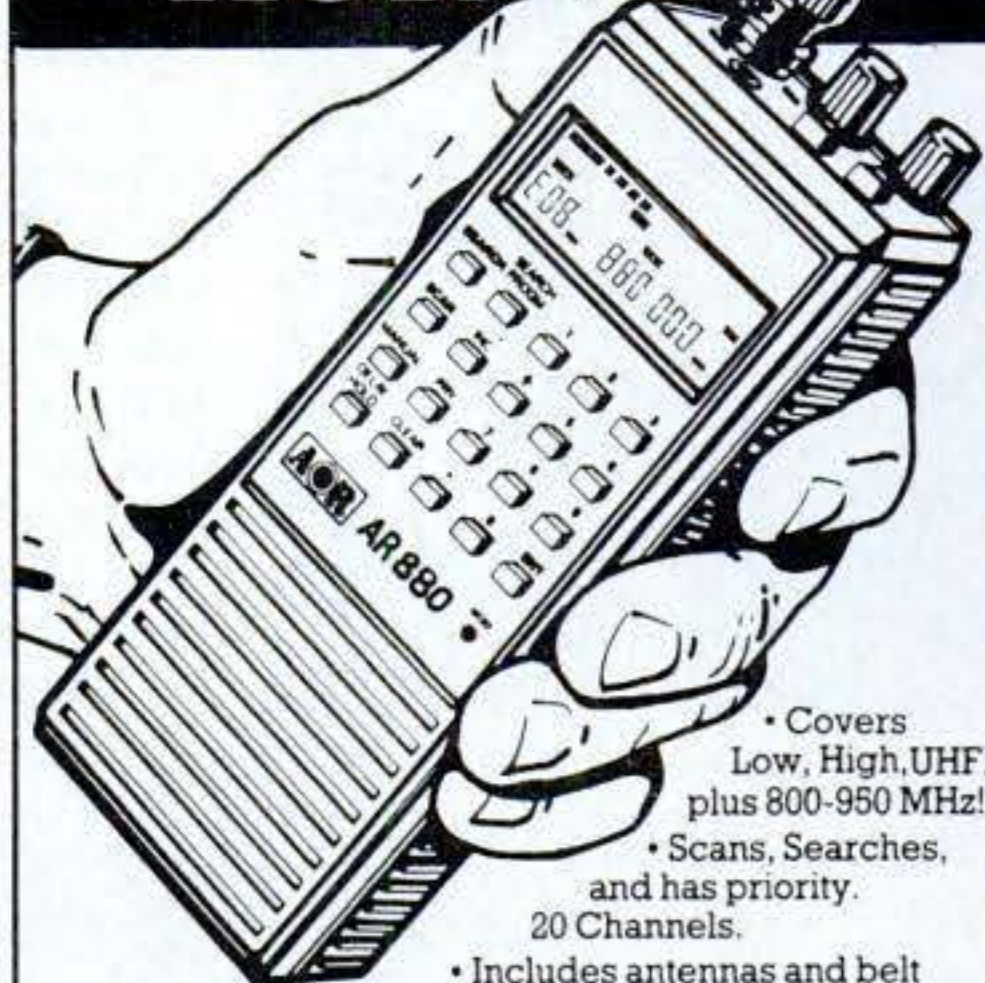
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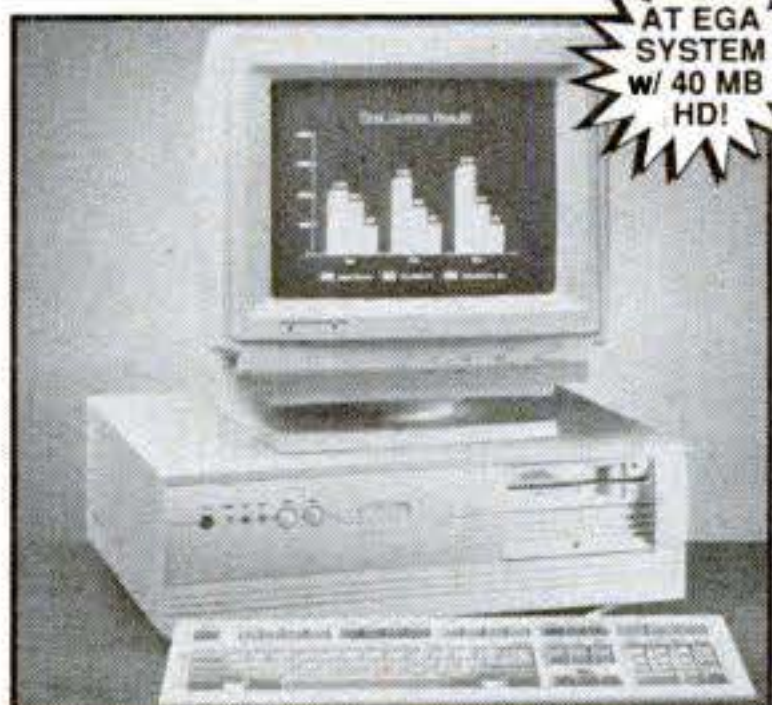
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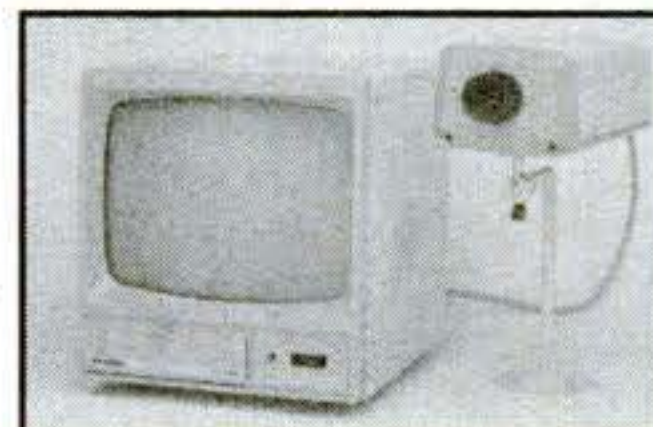
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TV news anchorwoman Connie Chung recently reported that "pick-up trucks without head restraints can be more dangerous than cars . . . in rear end collisions, heads can be whipped back violently . . ." which has proven lethal at speeds as low as 5 mph.

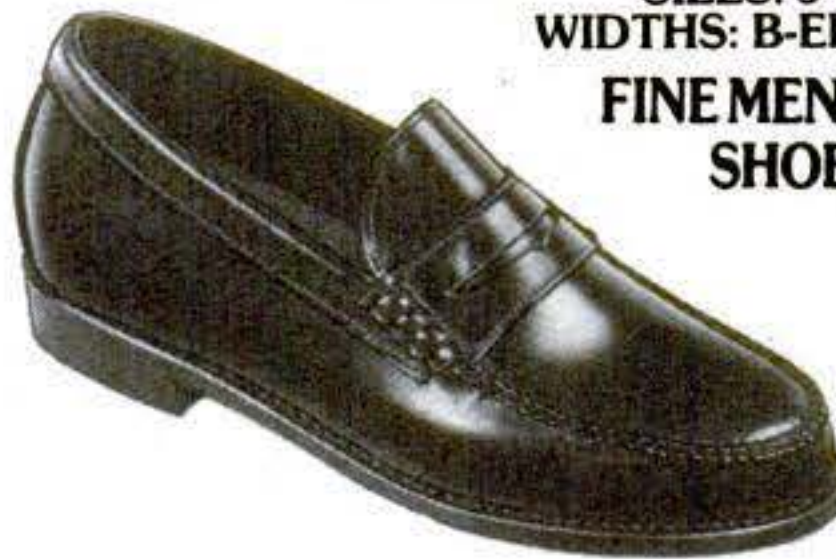
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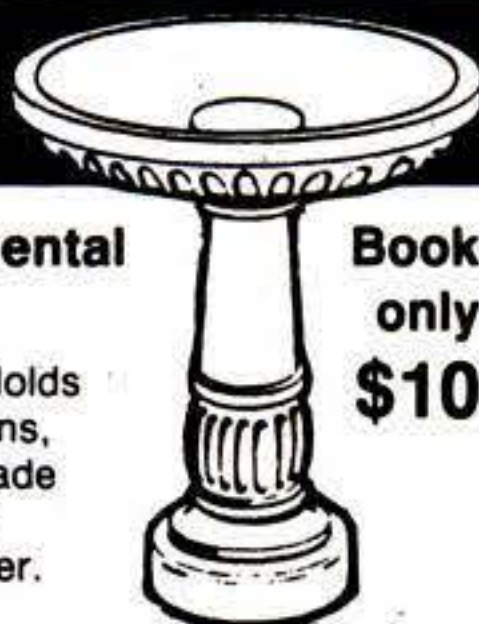
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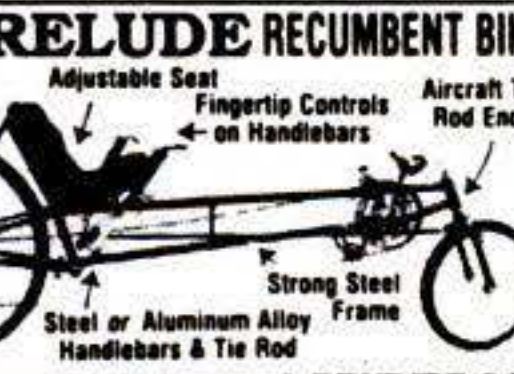
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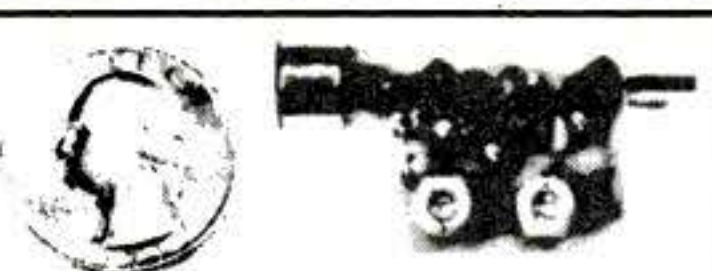
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1001 Thousands of Items American Design Components offers a catalog full of electronic and electromechanical components, plus a line of computer parts and peripherals. It's designed with the tinkerer, hobbyist, technician, and engineer in mind. Free

1002 Outdoor Storage Literature from Arrow Group Industries describes the latest in outdoor storage. Featured are steel and wood designs as well as children's playhouses. Also included are helpful storage, planning, purchasing, and creative storing-usage tips. \$1

1003 Radar Detection A Bel-Tronics brochure explains Ka Band photo radar equipment. Some of the questions addressed: Is photo radar legal? Where is Ka Band photo radar being used? Is photo radar the only type of equipment that can be used at Ka Band? Free

1004 Telescopes Explore the universe with Celestron telescopes. Premium-quality optics are available for everyone—from beginners to advanced researchers. This 28-page color brochure has complete specifications. \$1

1005 Telephones A brochure from Code-A-Phone describes its current line of telecommunication products—basic and feature phones, cordless phones, and telephone answering machines. These products are available from retailers nationwide. Free

1006 Personal-Computer Tips In its detailed color brochure, CompuServ describes how to obtain access to America's largest information service. Its data banks include an encyclopedia, news wires, and financial information. Free

1007 Kit Furniture Craftsman's Corner's Classic Oak kits offer roll-top desks, file cabinets, dining room and bedroom furniture, plus oak accessory kits at affordable prices. Limited woodworking skills required. \$1

1008 Auto Detailing The "Owning Your Own Custom Automobile Grooming & Detailing Business" brochure from Custom Car Care Publications provides extensive how-to information on establishing your own auto-detailing business. The brochure also includes an illustrated product-catalog section. \$8

1009 Fireplaces Colorful literature from Dovre, Inc. discusses the SunBurst woodburning fireplace, a zero-clearance model with a full fire-viewing area. A double-heat construction chamber and solid cast-iron construction delivers 60,000 Btu per hour. Free

1010 Hobbyist Catalog Edmund Scientific's 80-page catalog contains over 1,200 products, including telescopes, magnets, weather instruments, solar equipment, fiber optics, and ideas for science-fair projects. Free

1011 Country Homes The "Country Houses" book from Home Planners contains 80 designs, including distinctive Cape Cods, American farmhouses, and center-hall colonials. It features color illustrations showing how rooms might look when the houses are built. Construction blueprints are available. \$11.95

1012 Wood Finishing This edition of Minwax's 30-page finishing guide is complete with time-saving tips and how-to instructions. Learn how to beautify and protect new wood and restore old wood to its original beauty. Free

1013 Radial Tires A full-color brochure from Riken Tire describes its complete line of radial tires and aluminum modular wheels for high-performance automobiles. Free

1014 Lube Tips The "Lube Tips" brochure from the makers of Rislone Engine Treatment answers lubrication questions with information gathered from lubrication consultants, refinery technical reports, Rislone Racing Teams, and automotive service shops. Free

1015 Concrete Cleaner A brochure from Sakrete Products features Fade, a remarkable concrete cleaner that dissolves unsightly grease and oil stains. Fade penetrates the concrete or cement surface for deep cleaning. You simply scrub away the stains then rinse to improve the appearance of the concrete at your home or office. 50¢

1016 Home Security Does your house pass the security test? Find out with Schlage Lock Co.'s brochure. Many of the tips for protecting your house are offered by an ex-burglar. Free

1017 Recreational Vehicles The 32-page 1989 Sunline brochure describes more than 70 towable RVs and truck campers. It also includes options, floor plans, specifications, and Sunline's new, wider color selection. Free

1018 Wood Finishing The color-illustrated guide from United Gilsonite Labs offers tips on wood finishing, refinishing, and special stain effects. The guide provides how-to information for all phases of the wood finishing process—from removing old paint to choosing and applying new stain and protective finishes. Free

1019 Engine Treatment U.S. Auto-Tech's new full-color car-care catalog describes its line of unique engine and gas-saving products. Also featured is the KolorKey carnauba car wax that is safe on all types of car finishes, doesn't leave swirl marks, and comes in 10 different colors, including burgundy, silver, and light blue. \$1

1020 Electronic Level A brochure from Wedge Innovations describes its SmartLevel recalibratable digital electronic carpenter's level. SmartLevel measures all angles with up to 1/10-degree accuracy and is able to automatically calculate percent slope and rise over run. Free

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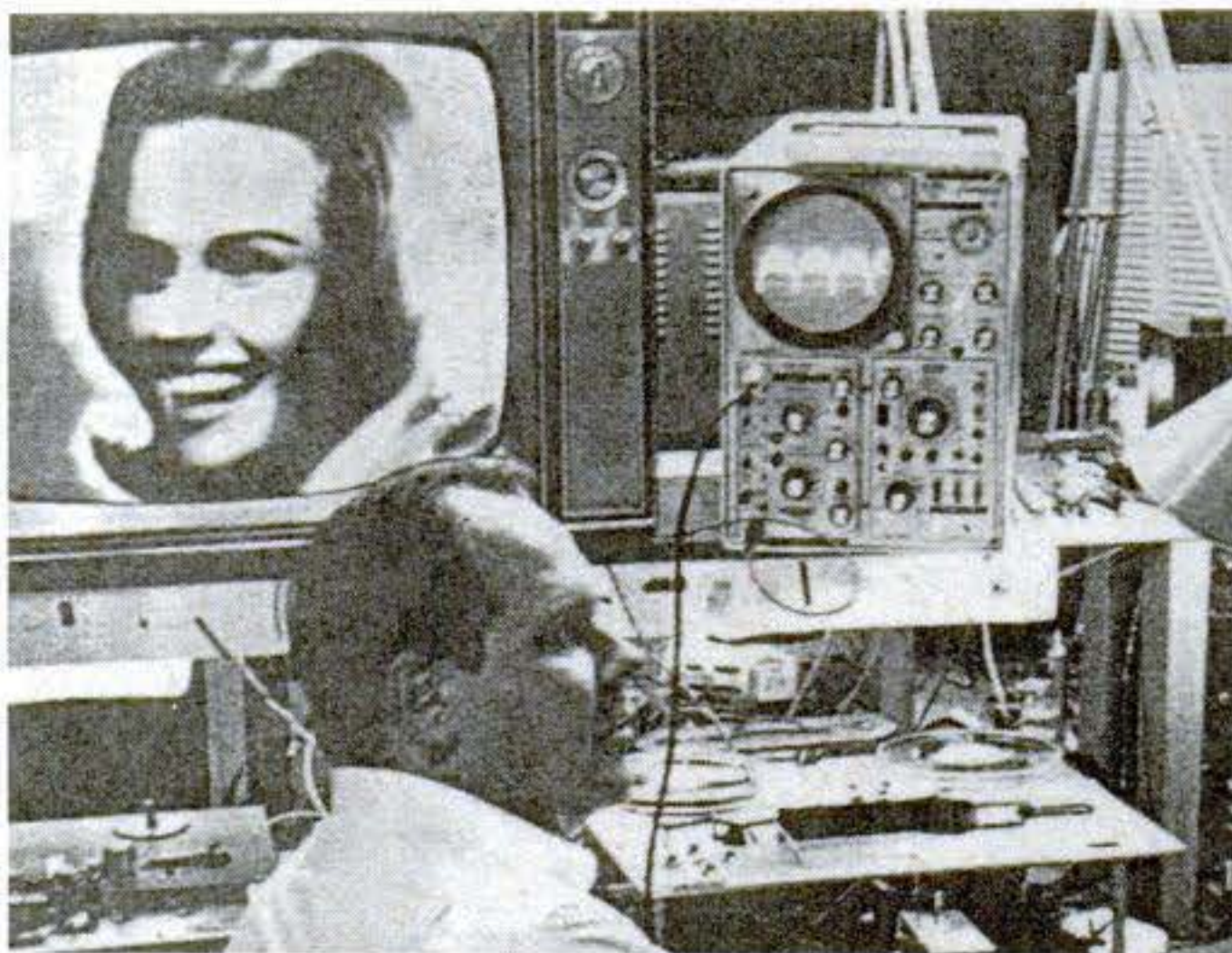
Sampling a century of POPULAR SCIENCE

25 YEARS AGO OCTOBER 1964

"There's a new entry in the red-hot race to give you a practical home-TV recorder that will capture video on tape: the Par Vision system developed by two electronic engineers. Stewart Hegeman and Robert Morrow, working in a basement laboratory, are now putting the finishing touches on the third experimental home videocorder to come out during the past year.

"Stewart Hegeman, a pioneer in high-fidelity equipment and audio tape-recorder design, predicts that home videocorders will do much more than just record

broadcasted programs for later viewing. He foresees a time when you will buy prerecorded shows across the counter, the way you now buy prerecorded music tapes. Pretaped TV programs



may be more practical than pay-TV.

"You'll also use your videocorder to record home 'movies'—a simple closed-circuit TV camera will photograph the action.

"A TV signal is a complex blend of high- and low-frequency components that fill a frequency band almost three megacycles wide. A videocorder must catch most of the band width, or picture definition and contrast will suffer.

"The traditional approach to wide-frequency-range tape recording has been to whisk tape past the recording head at 120 inches per second. The prototype Par Vision recorder runs at 60 inches per second, and will record a total of 24 minutes on both sides of a 3,600-foot reel of a newly developed high-quality audio tape that is ultrathin. Lower tape speed means longer tape and recording-head life, as well as lower operating cost."

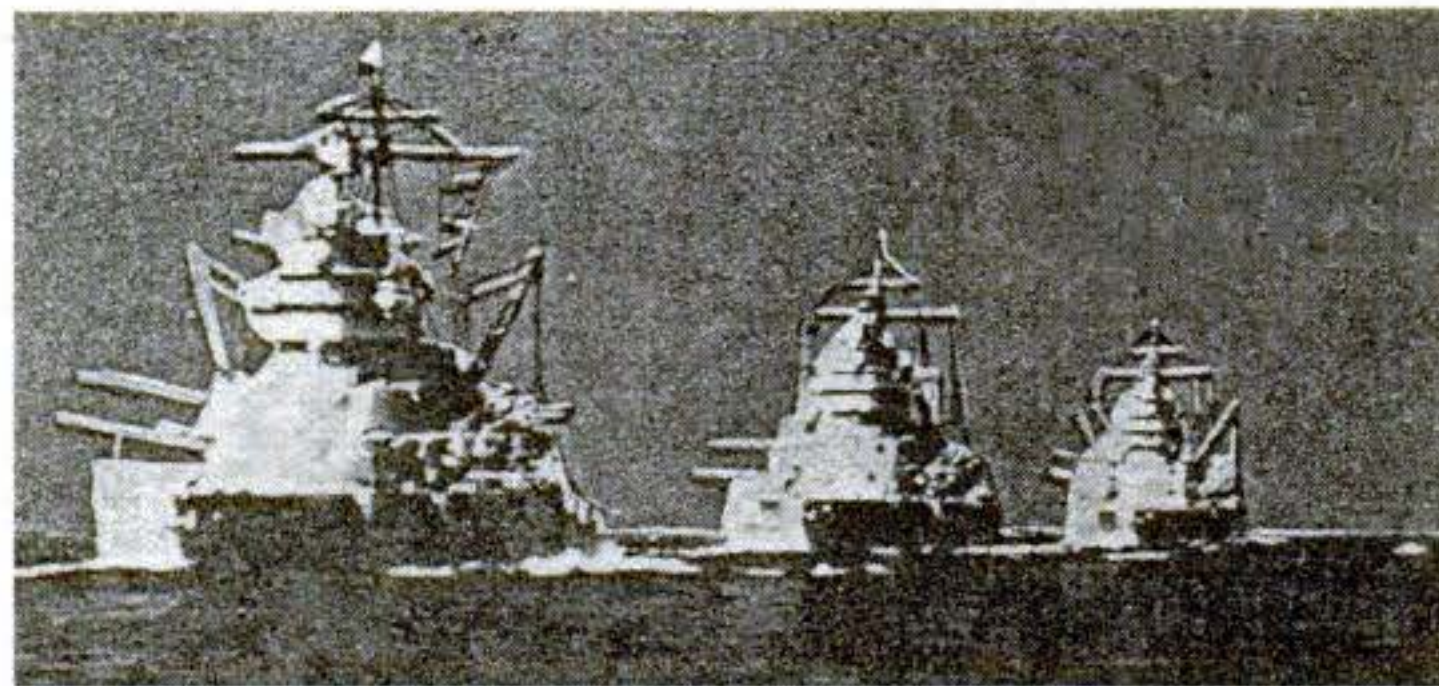
50 YEARS AGO OCTOBER 1939

"With lightning speed, the enemy has struck at America. A 'suicide squadron' of bombing planes has roared out of the sky to rain their missiles upon the Panama Canal. Before a lucky hit could strike the towering lock gates, a hail of antiaircraft fire has riddled the bombers. The few pilots who escaped have bailed out over Central American jungles—knowing that, before they could get back to their aircraft carrier, our own bombers would locate and sink it.

"The attempt to bottle up our fleet has failed, and the hos-

tile coalition of powers has dropped its mask. It is war, without the old-fashioned ceremony of a formal declaration—swift, ruthless, modern.

"Thus may come 'M Day,' the country's fateful day of mobilization. But any such challenge from overseas is being made unlikely—and our victory as nearly certain as human foresight can provide—by the most powerful



fighting machine America has ever forged in peacetime. Already off to a flying start, the gigantic armament program voted by the 'Preparedness Congress' of 1939 will make the United States more than a match for any conceivable combination of aggressors. And it will provide weapons more radical and deadly than any battlefield yet has seen.

"The Navy remains our first line of defense. Alone among the world's great nations, the United States is safe from mass attack by air or by land so long as its fleet commands its waters.

"Already the steel is being fabricated for two giant 45,000-ton battleships—the *Iowa* and *New Jersey*. Heading a list of 23 war vessels whose construction is to start this year, they will be the world's largest and most powerful warships."

100 YEARS AGO OCTOBER 1889

"Besides the orthodox system of protection against lightning, there is another system suggested by Clerk Maxwell—the 'bird-cage' or 'meat-safe' principle. 'In a banker's strong room,' says Professor Lodge, 'you are absolutely safe. Even if it were struck,

nothing could get at you. In a bird-cage, or in armor, you are moderately safe. A sufficiently strong and closely meshed cage or netting all over a house will undoubtedly make all inside perfectly safe from lightning—only, if that is all the defense, you must not step outside or touch the netting while outside, for fear of a shock.

An earth connection is necessary too.

"A wire netting all over the house, a good earth-connection at several points, and a plentiful supply of barbed wire stuck all over the roof constitute an admirable system of defense. Points to the sky are recognized as correct, but there should be more of them along ridges and eaves."

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